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ABSTRACT

Described are eight field trips to various sites on the Hawaiian island of Oahu. These experiences are designed to help teachers develop middle school students' awareness and understanding of Hawaii's natural resources, with particular emphasis upon coral. Each field trip unit contains a physical and biological description of the area and two to nine related activities. Also included are lists of goals, instructional objectives, performance expectations, and essential competencies from Hawaii's environmental education curriculum guide (SE 035 241). Appended are tide tables and a guide to marine invertebrates. (NB)

CORAL:
A Hawaiian Resource
An Instructional Guidebook for Teachers

By Ann Fielding and Barbara Moniz

Original draft of this guide was prepared by the Waikiki Aquarium under a grant awarded by the Environmental Education Program, Department of Education, State of Hawaii

Office of Instructional Services General Education Branch
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The Honorable George R. Ariyoshi
Governor, State of Hawaii

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Foreword

Hawaii is a small state, limited in both land area and natural resources. It is therefore vitally important that our citizens understand and appreciate the nature and limitations of the resources to insure that those resources are managed in the most effective manner to provide enjoyment, comfort, happiness, and opportunities for self-realization for all Hawaii's people now and in the future.

This guidebook has been designed to help teachers develop students' awareness and understanding of one of Hawaii's valuable resources--coral. Coral constitutes an important part of both Hawaii's land and sea environments and is important aesthetically, ecologically, politically, vocationally, economically, and geologically. While coral is a renewable resource, there are definite constraints on the degree of this renewability in terms of sheer growth rate and ability to survive adverse physical and biological conditions. Human beings have a definite impact on existing coral stocks and affect the environmental conditions which allow coral to grow.

This guidebook attempts to bring the interrelationship between humans and natural resources, in particular coral, into sharp focus so that public school students who are future citizens can learn to take responsible action in dealing with Hawaii's natural resources.

Charles G. Clark
Superintendent

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We would also like to thank the staffs of the Coral Grotto, Hemmeter Center and Sea Life Park's Waikiki Sales Office for their assistance and cooperation in arranging tours.

HOW TO USE THIS GUIDEBOOK

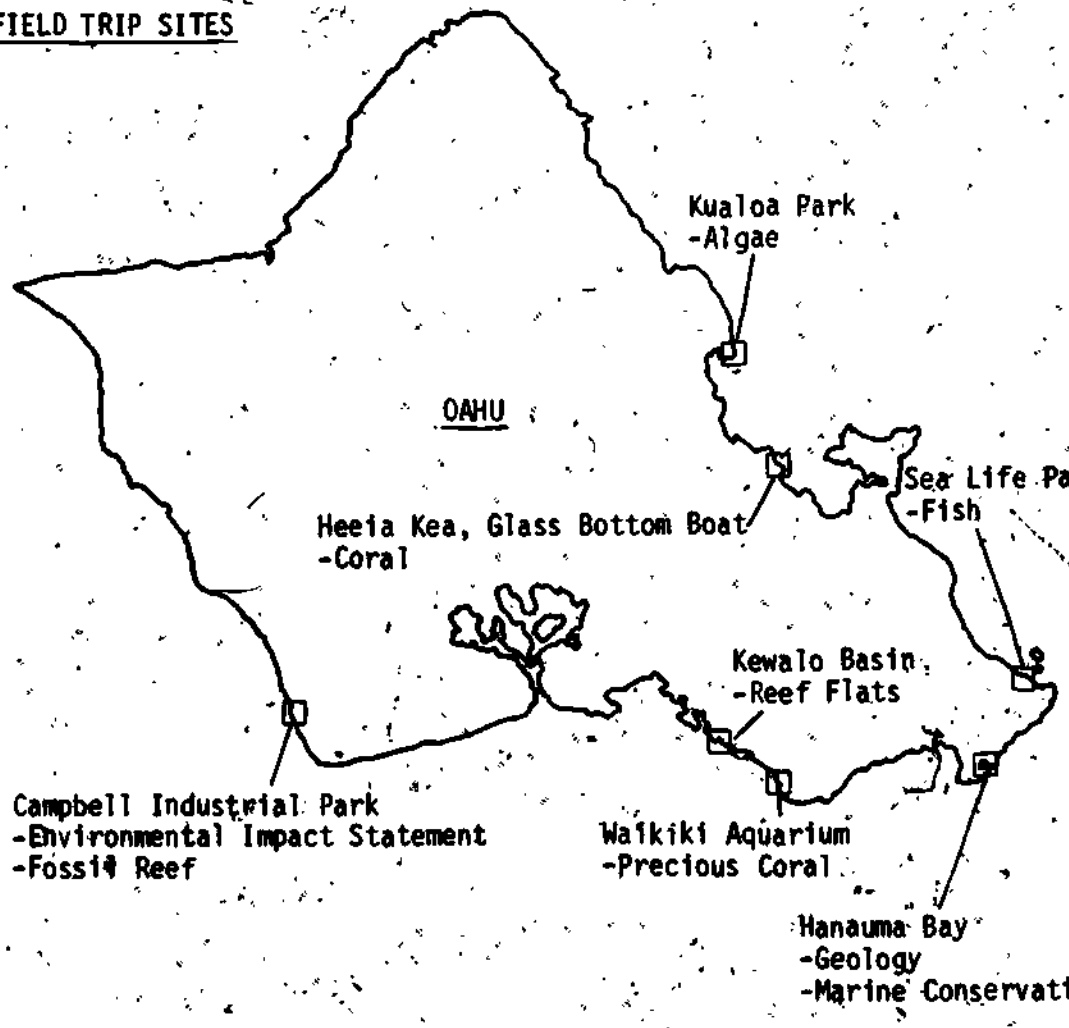
Although the material in this guidebook was primarily designed for intermediate level students, many of the activities have been used successfully with upper elementary and high school students in conjunction with a study of the marine environment.

The approach used in this guidebook reflects the direction of the Hawaii State Department of Education's Environmental Education Program and its philosophy that education in this area should be concerned with the interrelatedness of humans and their environment. This Guidebook attempts to give teachers a tool to help their students come to an understanding and appreciation of this interrelatedness.

It is not expected that a teacher will be able to take the class on all of these field trips or be able to do all of the activities. Each field trip is a unit complete within itself, although it also relates to all the other field trips in some way. Field trips are arranged into "topics" which are complete within themselves. Topics are divided into teacher background material, activities, and questions. Answers to the questions are provided parenthetically for the teacher when it was thought to be necessary. The background material is provided for your information and does not necessarily need to be the basis of a class lecture. Often, the information given as background will come out during the various activities planned for that topic and in the questions.

For each field trip the major instructional goals and objectives, performance expectations, and essential competencies from The Environmental Education K-12 Curriculum to whose attainment the activities can contribute have been delineated.

FIELD TRIP SITES



MAIN TABLE OF CONTENTS

FIELD TRIP I - KANEOHE BAY

FIELD TRIP I - KANEOHE BAY

Instructional Goals

When faced with decisions concerning the use of terrestrial and extraterrestrial resources, students will select practices developed in recognition of present and future environmental and humans needs.

Students will demonstrate an appreciation for the interdependence of living things in the closed earth system.

Instructional Objectives

Discuss the physical features of the coastal zone areas of Hawaii.	Sc, SS, HS
Explain why algae and coral are renewable resources and discuss the constraints on this renewability.	Sc, SS
Identify and explain important functions of algae and corals.	Sc, N
Give examples of how survival of an organism depends on its ability to adjust to its environment.	Sc, SS, H
Explain how people make the most of their adaptations through the use of their intelligence.	Sc, SS, H, N
Collect evidence showing how the "balance of nature" has become upset with the removal (or addition) of a species from (or to) an eco-community.	Sc, SS
Explain the complexities of an ecological problem within a given ecosystem.	Sc, SS, H, LA
Identify an ecological problem in the community and design a program to correct it.	SS, Sc, H, LA
Report on an overload system that they have observed.	LA, Sc, H, N
Formulate a hypothesis about how changed environmental practices may affect ecological balance.	SS, Sc, H
Discuss how the manipulation of one environmental element affects all elements.	SS, Sc, H
Suggest ways to guard against detrimental environmental manipulations of ecosystems.	Sc, H, LA, SS, V
Collect data to illustrate the change in algae species that result from increased detergent use.	Sc, H, SS
Identify industrial practices which minimize detrimental impacts on the environment.	SS, Sc, H, BPA, C

Performance Expectations

Cites examples of statewide, nationwide or worldwide environmental problems.

Cites examples of social, political, or economic decisions which have caused environmental problems.

Uses a variety of resources to gain information on environmental matters.

Conducts simple investigations to gain first-hand information on environmental matters.

Describes instruments or methods that can be used to gain information about environments or change an environment for a desired result.

Integrates information gained from resources with information gained through direct experiences to develop understanding of environmental matters.

Describes the impact of various industries on the environment.

Cites examples of negative and positive ways human being can change the environment.

Describes the effects of environmental changes on the beauty of an environment.

Identifies state and federal government agencies primarily concerned with environmental management or control.

Identifies non-government groups primarily concerned with environmental matters.

Describes the responsibilities of state and federal agencies for environmental management or control.

Describes the functions of non-governmental groups concerned with environmental matters.

Identifies state or federal laws designed to protect people and the environment and discusses their effectiveness.

Identifies specific contributions one can make to help human beings live in harmony with the environment.

Essential Competencies

Reach reasoned solutions to commonly encountered problems.

Use resources for independent learning.

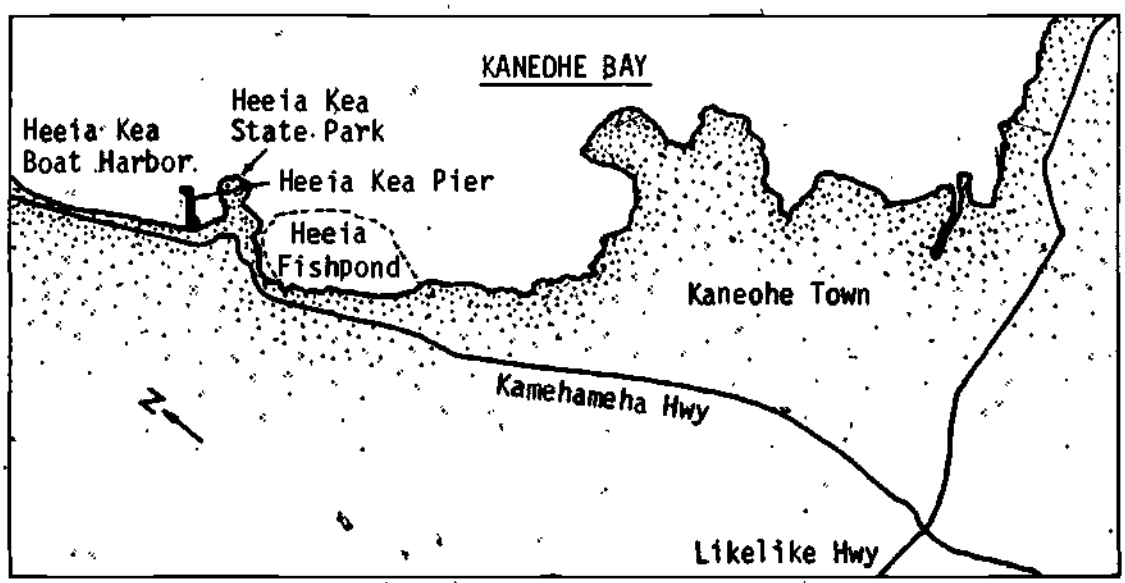
Demonstrate knowledge of the basic structure and functions of national, state, and local governments.

Demonstrate knowledge of important citizen rights and responsibilities.

TOPICS DISCUSSED:

1. WHAT CORAL IS; WHERE IT GROWS; ITS BIOLOGICAL NEEDS; AND TYPES OF CORAL REEFS.
2. KANEOHE BAY AS A HABITAT FOR CORAL; PAST, PRESENT AND FUTURE.
3. THE IMPORTANCE OF PLANKTON.

FIELD TRIP SITE: Coral Gardens Glass Bottom Boat, Heeia Kea Pier, Kaneohe.



The Glass Bottom Boat offers a view of the different kinds of reefs in the bay, living coral, and coral covered with "green bubble alga". It also offers an opportunity for students to see plankton and animals associated with the reef. The Glass Bottom Boat offers either 1 or 2 hour cruises of the bay. Call 247-0375 for cost information and reservations. See appendix for a description of programs available. Heeia Kea Pier has restrooms and a snack bar.

INTRODUCTION

Kaneohe Bay is a unique Hawaiian habitat. It is the largest protected body of water in the state; it supports large expanses of living coral; it has examples of three different types of coral reefs; it has been the center of environmental controversy for the past decade. There is much about the bay that is of environmental interest. The field trip into the bay on the Coral Garden Glass Bottom Boat allows students to see the different types of reefs, reef animals and plankton at close hand. Pre-field trip activities will help students understand what they see in Kaneohe Bay.

PHYSICAL DESCRIPTION

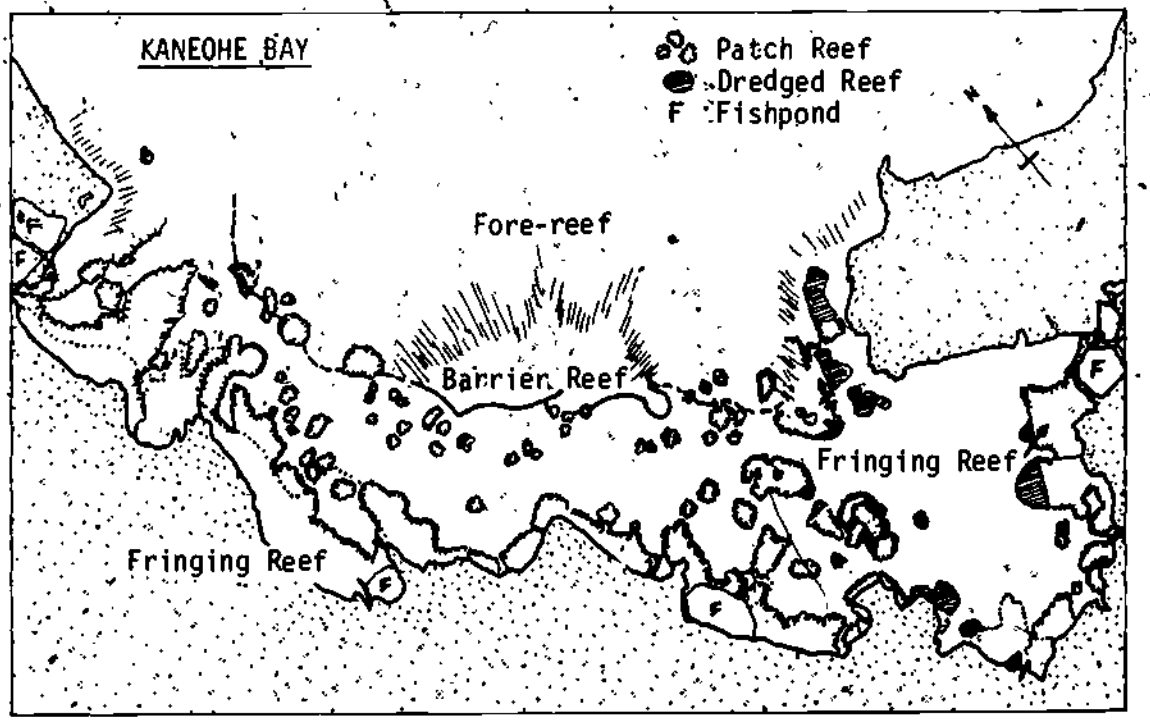
Kaneohe Bay is the largest protected body of water in the state. It is 12.5km long, 4.1km wide at the center, and 20m deep at its deepest point. It provides excellent examples of different kinds of coral reefs. The bay is protected from the ocean by an extensive barrier reef which runs across its mouth and breaks the force of the waves. Barrier reefs are characteristically separated from the land by a deep lagoon channel. Other reefs include scattered patch reefs, which are small, isolated reefs; and fringing reefs which grow along the margin of the land.

Two channels, one at either end, facilitate the exchange of bay water with fresh ocean water. This exchange is not adequate to completely flush the south end of the bay, making this part a "semi-isolated lagoon".

BIOLOGICAL DESCRIPTION

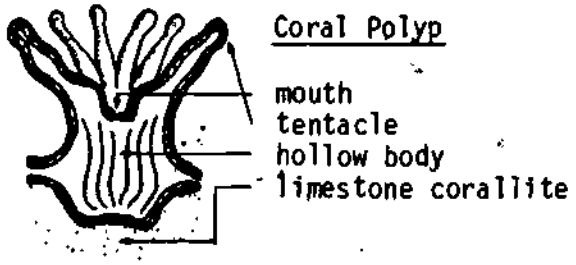
Biologically, the interior of Kaneohe Bay is a "protected coral

community", due to the presence of the barrier reef. This habitat supports corals which grow well in calm water. The dominant coral is the "finger coral", Porites compressa. This coral grows tall and thick, providing crevices and holes for fish and bther animals to hide in. Because it provides so much protection, it can support a great deal of life.



TOPIC 1: WHAT CORAL IS, WHERE IT GROWS, ITS BIOLOGICAL NEEDS

Most corals are colonies of many small sea anemone-like animals called polyps.

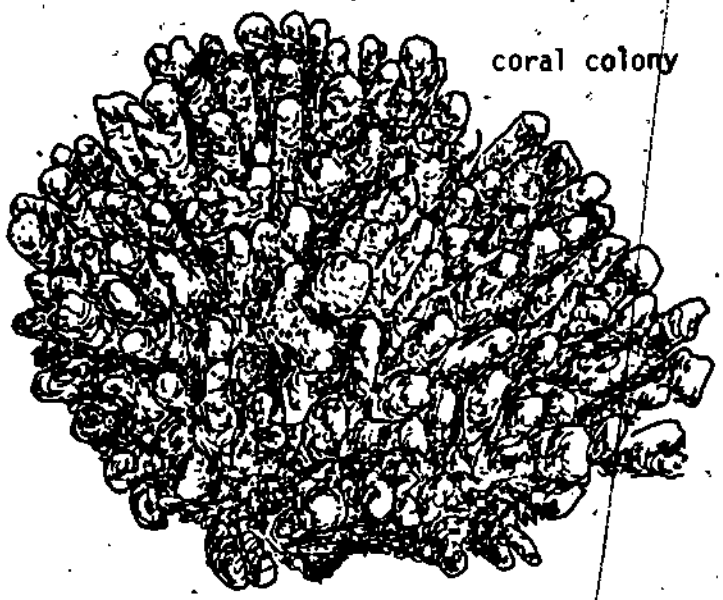


Each polyp secretes a small cup-like structure of limestone, called a corallite. The corallite provides support and protection for the soft-bodied polyp which is able to retract into the corallite when not feeding.

The polyp has a circlet of tentacles surrounding a central mouth, which opens to the hollow body cavity. The tentacles are armed with stinging cells that enable the coral to capture small floating animals called zooplankton.

Some corals, such as the mushroom coral, (Fungia), are single polyps, but most grow in colonies. In the colony the polyps are inter-connected by tissues that lie as a thin skin over the non-living skeleton. The polyps are continually secreting calcium carbonate which causes the colony to expand outwards and upwards.

coral colony



The skeleton gives the coral colony its shape, while the living tissue gives the color. Removal of this thin layer of tissue leaves, with few exceptions, a white skeleton.

Corals can reproduce by asexual or sexual methods. Asexual "budding" results in the growth of the colonies by the subdivision of existing polyps; while sexual reproduction results in a tiny planula larva which swims away to form a new colony.

Some corals are called "reef-building" or hermatypic corals, and this alludes to their efficient production of calcium carbonate. This ability is enhanced by a symbiotic (mutually beneficial) relationship with marine plants. Reef corals contain tiny one-celled yellow-brown algae called zooxanthellae in their living tissues. These algae are so numerous as to give the living coral a brownish hue (although the color can be overridden by the coral's own pigments).

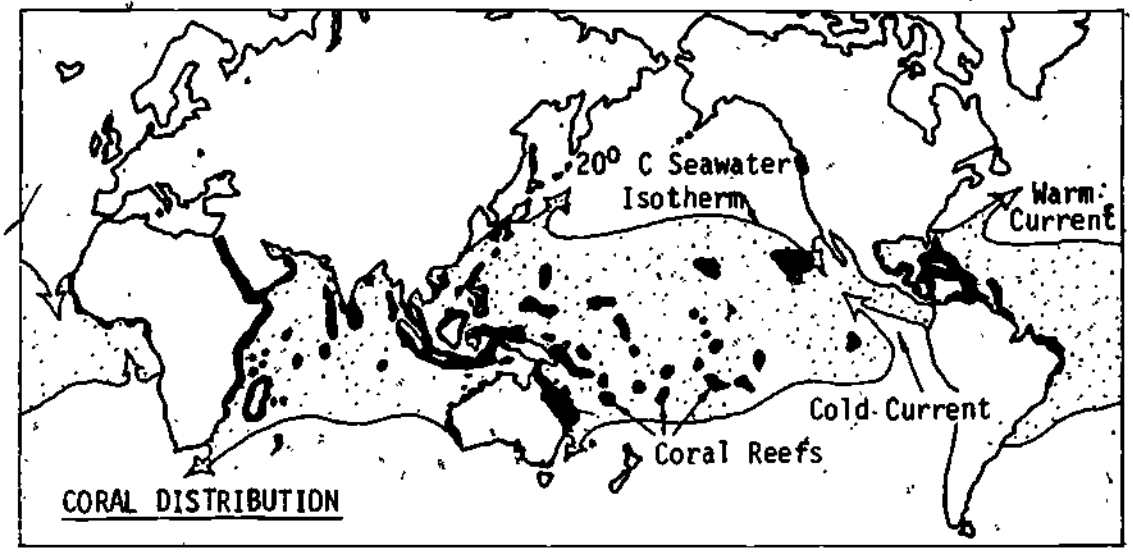
In the coral-zooxanthellae relationship, the zooxanthellae receive:

1. protection within the coral tissue;
2. carbon dioxide produced by the coral which they use to make carbohydrates during photosynthesis;
3. nitrogen and phosphorous from the coral's waste products. These nutrients are in greater concentrations in the coral tissue than they are in the sea and are essential elements in plant growth.

The corals, on the other hand, receive:

1. nutrition, in the form of soluble carbohydrates which are leaked from the zooxanthellae;
2. an increased ability to produce calcium carbonate, the exact mechanism of which is not known.

Since zooxanthellae are plants, and must have sunlight for photosynthesis, the growth of reef-building corals is restricted to clear, shallow, sunlit water. Temperature appears to be important also, as these corals flourish only in warm oceanic water between 20°C (68°F) and 30°C (86°F). The requirements for warm water and abundant sunlight restrict reef-building corals to the tropics.



CORAL DISTRIBUTION

Corals have a limited tolerance to sediment, changes in salinity (salt content of the water), and exposure to air. They also require adequate water movement to provide food and oxygen.

Corals are the most important group of animals on a reef contributing to general habitat diversity. Coral reefs are characterized by having an irregular surface with many holes and caves and their accompanying changes in light and water movements. Generally, a more complex environment will support more animals of different sorts than a simple one (see "Habitat Diversity", In-Class Field Trip).

"When it is realized that the stony corals are the key species in the overall reef ecosystem, it can be appreciated that the destruction of all or most of the living corals on a reef would have a drastic and immediate effect on the entire reef community."1. This is a good point to keep in mind as you begin the study of Kaneohe Bay.

1 Deas, W. and S. Domm, 1976. Corals of the Great Barrier Reef. Ure Smith, Sidney; 127pp.

ACTIVITY I - Pre-Field Trip

Objective: To understand the basic biology and ecology of living coral.

Procedure: Dr. Art Reed of the Zoology Department of the University of Hawaii has prepared the film strip "Living Coral: How It Grows and Reproduces" to be used with this unit. This film strip can be obtained from your district office. It is very important that students view this film strip at the beginning of their study of corals, as it gives basic background information that they will need. You may find it useful to show the film strip again after the class has discussed the filmstrip in order to clarify points brought up in the discussion.

ACTIVITY II - On-Site

Objective: To recognize fringing reefs (those associated with the shoreline); patch reefs (isolated in the bay); and the barrier reef (located out at the mouth of the bay). (To locate the barrier reef, look for surf breaking on the front of it).

Procedure: Ask students to point out the different kinds of reefs as you see them.

ACTIVITY III - On-Site

Objective: To relate the different colors of the water to the changes in depth and substrate on the reef.

Procedure: As you pass the reefs, have the students notice the color changes and answer the following questions:

1. Why is the water different colors? (Different depths and different materials on the reef tops.)
2. As you approach a reef can you guess the type of bottom that each color refers to?
3. Once the boat is stopped on the reef, look through the bottom of the boat. What are the different kinds of materials that cover the bottom? (Live coral, dead coral rubble, sand, green bubble alga)
4. Can you relate these different bottom types to the different colors of the water?
5. Can you think of any reason why it would be useful to be able to tell bottom type and depth from the colors they give through the water? (For fishing or navigating a boat)

ACTIVITY IV - On-Site

Objective: To observe marine life living hidden within the reef.

Procedure: Once on the reef, the crew of the boat will collect large chunks of green bubble alga for students to break apart. Many animals live within the folds of this alga because it provides protected areas where animals can hide from predators.

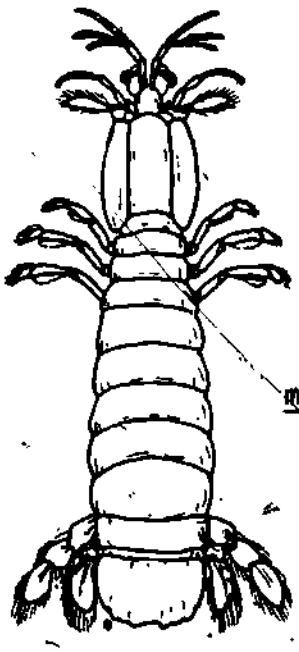
What other plants or animals on the reef might provide a similar habitat? (Living coral provides homes and protection in the same way. If you were to break up live coral you would see similar kinds of small reef animals).

This activity shows that there are more animals on the reef than you would think.

Identification of animals in the green bubble alga:

Common animals found in the alga are colonial filter feeders. These are encrusting colonies of tiny animals. They may be smooth and white, dotted with small holes, or hard and crusty. The white ones are colonial tunicates, and the crusty ones are bryozoans. Brightly colored sponges are common too. They are soft and spongy to the touch.

Crustaceans such as crabs and shrimp are common, but look for an inch long green one called a mantis shrimp. Large mantis shrimp can be harmful, as their claws can give a deep cut. These small ones are harmless to humans.



mantis shrimp

You'll probably see segmented worms with tiny bristles along their sides, and perhaps a tiny 6 or 7 armed starfish.

Appreciate the great variety of tiny creatures that live hidden away in the reef.

TOPIC 2: KANEOHE BAY AS A HABITAT FOR CORAL - PAST, PRESENT AND FUTURE

Until the early 1960's, Kaneohe Bay was well known for its clear water and coral-rich environment. The bay was a favorite place for fishing, boating, water-skiing and swimming. As the population of Oahu grew and highways were built ot the windward side of the island, the population around scenic Kaneohe Bay also began to grow. As housing developments were built, vegetation was stripped from the hillsides, leaving the soil exposed. The heavy rains that occur on this side of the island eroded the soil, washing it into the bay. Asphalt and concrete covered the watershed increasing the impervious surface areas, and therefore causing increased freshwater runoff into the bay. Flood control channels were built, taking the place of natural streams, again causing the rainwater to rush into the bay rather than sinking into the earth. Sediments eroded from the bared land and carried in the runoff waters were no longer deposited downstream but transported via these smooth channels into the bay. After a heavy rain much of the bay, particularly the southern portion, becomes a characteristic red-brown color as a result of this erosion and soil transport.

Increased urbanization also brought increased sewage, and from the 1940's until 1978, sewage was dumped into the south end of the bay. Since there are only two deep-water channels into the bay, circulation in the bay, especially in the south end, is poor. However, circulation was adequate as long as the biological stresses were few. As soon as large amounts of silt, freshwater runoff and sewage began pouring into the bay, the circulation was no longer adequate to cleanse the area.

The sewage acted as fertilizer for the algae in the bay. Phytoplankton (plant plankton) began to bloom (show a rapid population increase) causing the water to become green and murky thus decreasing the amount of light reaching the corals. The "green bubble alga", Dictyosphaeria cavernosa, began to grow to giant size, in some cases overgrowing and smothering the corals.

Corals are sensitive animals. They need clean seawater of a normal salinity and adequate light so that the tiny algal cells within their tissues can photosynthesize. They are able to cleanse themselves of a small amount of silt but are smothered under large amounts. New coral colonies must have a hard, non-shifting surface to grow on. All of the environmental stresses heaped on the bay were detrimental to the corals, and because the corals provided a habitat for great multitudes of marine life, these also decreased.

New kinds of marine life began to dominate the south end: huge growths of sponges, long orange sea cucumbers, large expanses of zoanthids (colonies of sea anemone-like animals), and the already mentioned "green bubble alga". These life forms were able to take advantage of the new environmental conditions. The south end of the bay wasn't "dead", but the environment had definitely shifted to a less aesthetically pleasing one.

zoanthids

In the mid-1970's Kaneohe Bay became a heated environmental issue. The film "Cloud Over a Coral Reef" documented the plight of the bay in a highly emotional fashion, and public pressure demanded that governmental officials take action. Plans for the sewage to be dumped outside of Kaneohe Bay were made, and in 1978 it became a reality. Some changes are not reversible, however, and it is likely that the bay will never be completely as it was. Nutrients and toxic chemicals stored in the sediments will continue to be released for some years. Algae will continue to be abundant. Some corals may never recolonize in damanged areas, and when recolonization does take place, reef formation and community development will take many years.

Still to be solved is the problem of silt and freshwater runoff, because they will continue to hamper the spread of living coral reefs back into damaged areas. The Environmental Protection and Health Services Division, Department of Health, State of Hawaii, is working on solving Hawaii's water quality problems. See the appendix to this section for a discussion of "Regulations and Procedures Controlling Water Runoff and Sedimentation".

ACTIVITY V - Pre-Field Trip.

Objective: To understand how a coral reef can be destroyed.

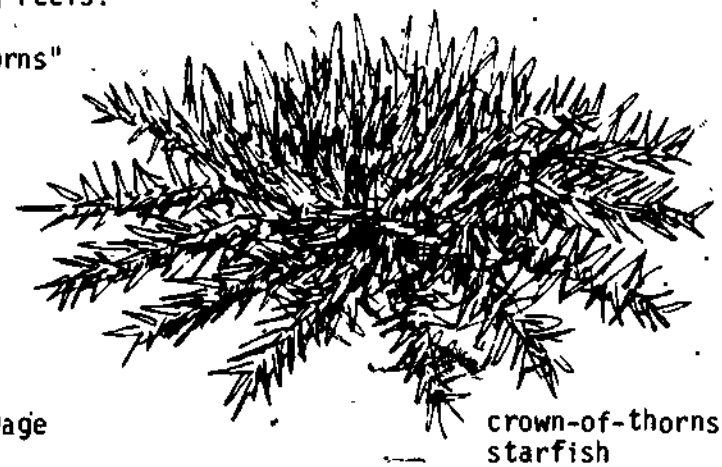
Procedure: As previously mentioned in the Biological Description of Kaneohe Bay, the film "Cloud Over a Coral Reef" was instrumental in ralling support to save the bay. It is essential that students see this movie to get the most out of the Kaneohe Bay field trip.

"Cloud Over a Coral Reef" can be obtained from the Main Branch of

the State Library, Department of Education Audiovisual Services Unit or from the Audio Visual Services, Sinclair Library, University of Hawaii. The State Library will take reservations for the film up to 1 month ahead of the time it is to be used and will loan it for 4 days. UH requires a written request for the film at least 3 working days prior to the day of use. There is no charge at the libraries.

Main points presented in the movie:

1. The different kinds of reefs (patch or button, fringing, barrier, atoll).
2. Why reefs are beneficial to marine animals and humans.
3. Threats to living reefs:
   a. "crown-of-thorns" starfish,
   b. siltation, dredging, sewage (this part was filmed in Kaneohe Bay).



crown-of-thorns starfish

The following questions can be used for a discussion of the movie:

1. What are the names of the different kinds of coral reefs shown in the movie? (atoll, barrier, patch or button, fringing.)
2. What do coral reefs provide for marine animals? (Protection, homes, food.)

3. What do coral reefs provide for islands? (Protection from wave erosion.)
4. What do the coral reefs provide for humans? (Food, aesthetic enjoyment, recreation-diving, surfing)
5. What kinds of things threaten living coral? (Crown-of-thorns starfish, silt, sewage, dredging, green bubble alga)
6. Why can't corals grow in areas covered by silt? (Corals need a hard surface to attach to.)
7. Why are the effects of sewage pollution worse in Kaneohe Bay than in offshore areas? (Poor circulation in Kaneohe Bay.)
8. What kinds of plants and animals thrive on the pollution in the bay? (long orange sea cucumber, sponges, green bubble alga.)
9. What part of the bay showed the worst affects of pollution? Why? (South end, because of poor circulation, site of outfall, advanced urbanization.)
10. How did this movie make you feel?

ACTIVITY VI - On-Site

Objective: To see Kaneohe Bay today, in the light of its history.

Procedure: Use the following questions to focus students' observations of the bay.

1. Look at the Koolau Mts. What do the steep, deeply eroded, lush palis tell you about this area? (Lots of rain.)
2. How many bare, red hillsides do you see? How many areas of new construction activity?

3. When the boat is over the patch reef, look for the green bubble alga. Is it still growing over the corals?
4. Look at the color of the deep water. Does it have a greenish cast from excess phytoplankton, or a reddish cast from recent land runoff? When you go over the patch reef does the water seem clear or murky?

TOPIC 3: THE IMPORTANCE OF PLANKTON.

Plankton is a very general term applied to small aquatic organisms whose relatively weak swimming capabilities result in their being randomly carried about by the ocean's currents. Plankton includes both plants (phytoplankton; phyto=plant) and animals (zooplankton; zoo=animal). In the ocean the phytoplankton are the primary producers. In a manner similar to that of land plants they provide the link between the sun's energy and all of the animals higher in the food web. Small zooplankton eat phytoplankton, and are in turn eaten by larger zooplankton and small fish, and so on.

Corals also utilize plankton as food, but rather than actively pursuing their prey, corals remain stationary on the bottom and depend on water movements to replenish their food supply. The plankton are captured by the tentacles surrounding the mouth of each polyp.

Some zooplankton are wholly planktonic, spending all of their life drifting in ocean currents. Other types of animals are represented in the zooplankton only during their larval stages. Corals are such animals, releasing their planulae as plankton into the water to disperse to new locations. This explains why similar corals, and other animals as well,

may be found at opposite ends of the ocean.

ACTIVITY VII - Pre-field trip.

Objective: To understand what plankton is and its importance in the oceanic food chain.

Procedure: "Plankton - Pastures of the Ocean" (F551), 10 minutes. This film is available through Audio Visual Services, Sinclair Library, University of Hawaii or Department of Education Audiovisual Services Unit. For Sinclair Library request the film in writing at least 3 working days prior to use.

Questions for class discussion on plankton:

1. Can plants that live in the sea live in both deep and shallow water? Explain. (Plants in the sea must live in shallow water so that they have sunlight for photosynthesis.)
2. What is chlorophyll used for? (To trap the sun's energy for use in the food chain.)
3. Why are plants important in the food chain? (They are able to produce food for animals using the sun's energy.)
4. What are diatoms and dinoflagellates? (Planktonic plants)
5. What kinds of animals only spend their larval stages in the plankton? (Fish and animals which live on the bottom, like crabs, lobsters, sea urchins and sea stars.)
6. Why do scientists study plankton? (They hope it will provide food for human populations. It also gives information on the distribution of larval forms and on ocean currents.)

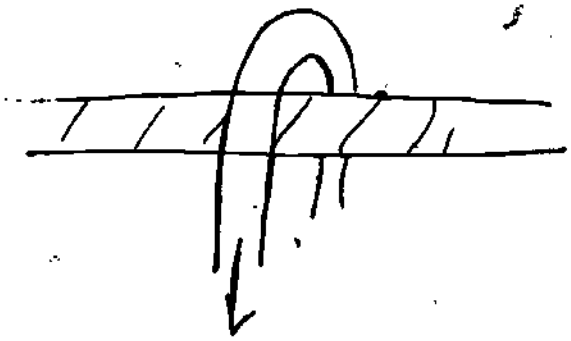
ACTIVITY VIII - Pre-field trip.

Objective: To prepare for doing Activity IX by learning to tie knots.

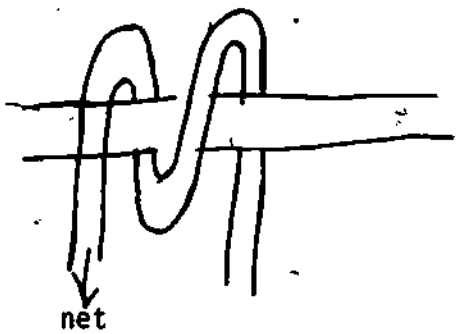
Materials: Rope (clothesline works well)

Procedure: Use diagrams on the following pages to prepare student to secure their plankton nets to the ship's railing.

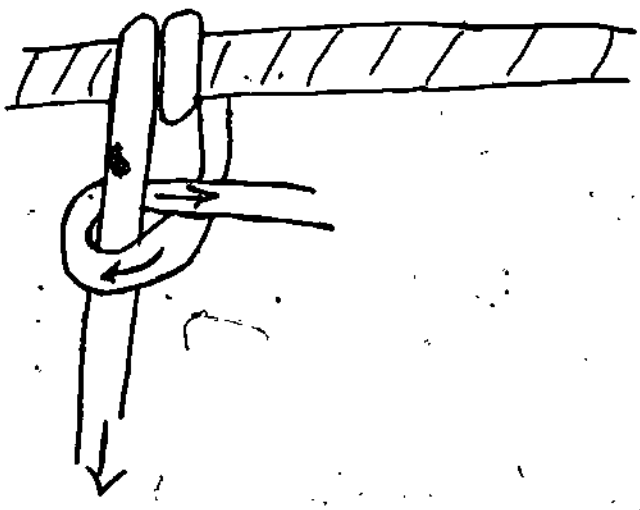
A round turn and two half hitches

1. 

Cross over and under,

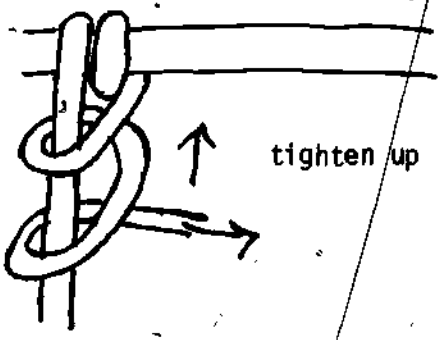
2. 

then over and under again,

3. 

pass free end over line attached to net and through loop. Tighten, repeat one more time.

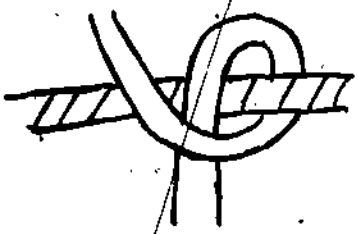
4.



Clove Hitch

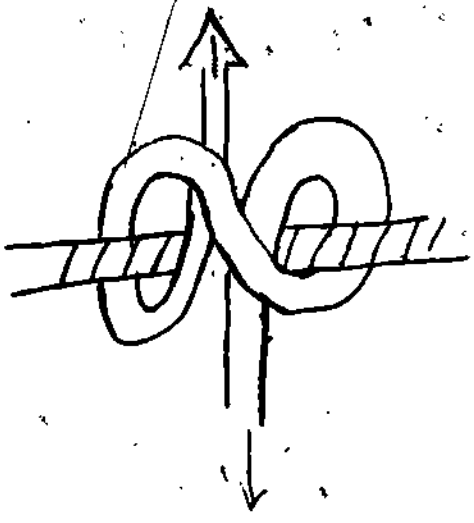
Used as a secure hitch around anything

1. Loop around, cross over,



2. Around again, over, then under itself.

3. Tighten



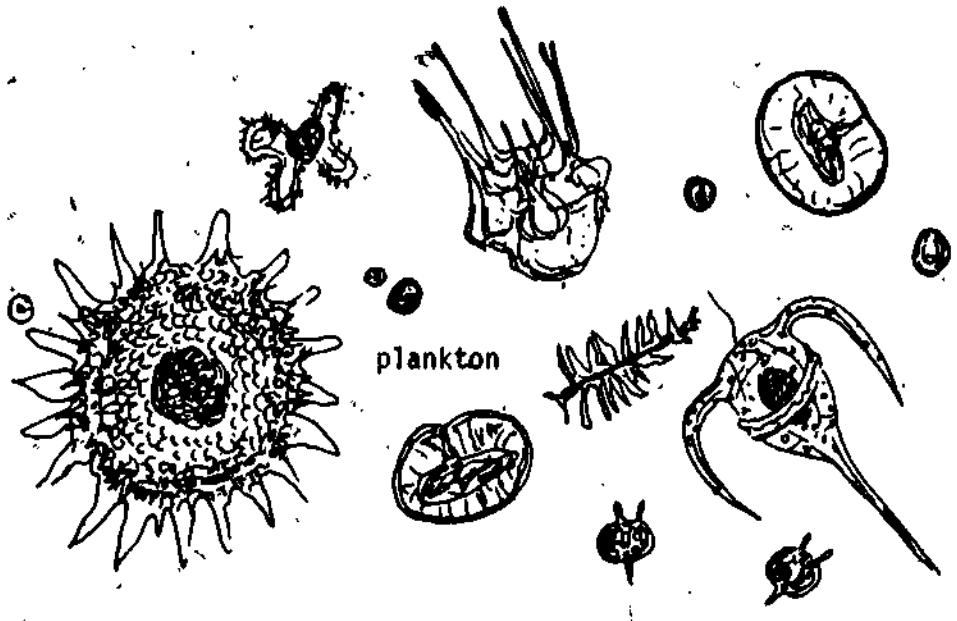
plankton net

ACTIVITY IX - On-Site

Objective: To see live plankton.

Materials: Plankton net. When you make reservations for the cruise, let them know you want to do a plankton tow. You can use their net, or students can make their own. (See appendix for instructions.)

The tow should begin as soon as the boat has cleared the harbor. (Be sure to stagger the lengths of rope for the nets behind the boat so they do not bump one another.) The plankton will be caught in a small bottle at the end of the net. Pass this around for everyone to see. Planktonic animals are small, usually clear, and come in a variety of shapes.



(Refer to Blue Water Marine Laboratory Cruise Guide in Appendix for identification materials.)

Questions on Entire Unit.

Discuss the interaction of humans and reefs:

1. What are the functions of a reef? (Protect islands from wave erosion, provide habitat for marine plants and animals) What benefits do humans derive? (Food, surfing, and other recreation activities, aesthetic enjoyment)
2. What do reefs require to develop and maintain themselves? (Clear water, normal salinity, sunlight.)
3. How can humans influence reefs? (Dredging, land runoff, dumping of wastes, cloroxing for fish, taking coral)
4. What sorts of measures could be adopted to protect reef resources? (Initiate fishing management, restrict coral harvesting, and control dredging, siltation, freshwater runoff, sewage, insecticides, and introduction of new animal species.)

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Teacher's Guide
Rose Pfund, Coordinator

PLANKTON

In the study of ocean life, it is with the plankton that all things begin. The word plankton means "drifter" or "wanderer". Hence, all plankton are those creatures that must drift at the mercy of the currents because they are either too weak or too small to swim against those forces.

The kinds of things included in the plankton are such things as larval fish, baby crabs, tiny shrimp, bug-like creatures called copepods, one-celled plants called phytoplankton, and many, many, many other tiny creatures of the sea.

The plankton live in the surface waters of the ocean, and serve as the ultimate food source for many of the sea's larger creatures.

A HOMEMADE PLANKTON NET

Scientist have special nets with which to capture plankton. The net is towed through the water behind a ship for 5 to 10 minutes, then is brought aboard for examination. This is how you can make a net using simple materials you may find around the house.

MATERIALS NEEDED: nylon stocking or pantyhose, scissors, needle and thread, wire clothes hanger, pliers, about 15 feet of line, and baby food jar.

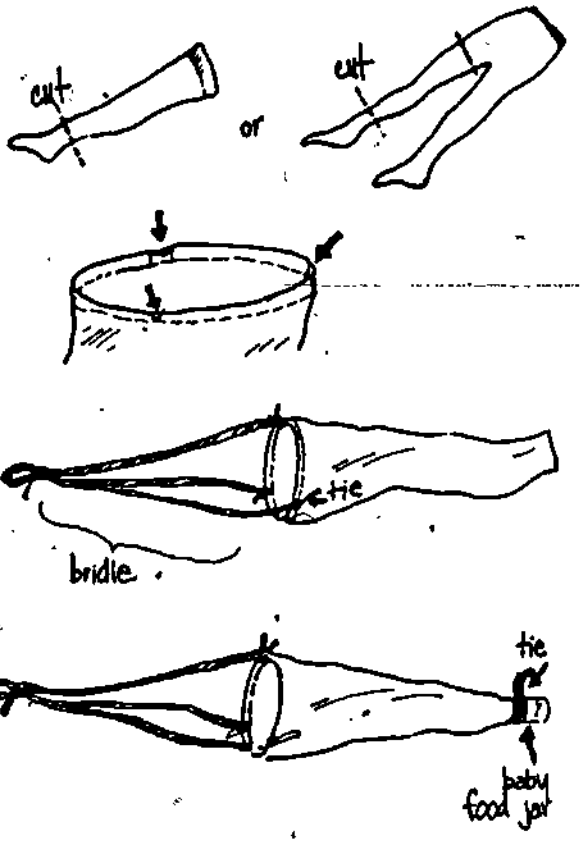
STEP 1: Form a ring from the wire hanger, twisting the ends to form a smooth joint.

STEP 2: Cut the stocking as in the diagram.

STEP 3: Sew the stocking onto the ring, leaving 3 evenly spaced ¼" gaps where the bridle will be tied.

STEP 4: Fashio a bridle, knotting three 2' lengths of line together on one end. Tie the other ends to the hoop at the gaps.

STEP 5; Sew a hem on the other end of the stocking net so that it dose not ravel. Then tie the jar on to the end of the completed net. Now you are ready for your first tow!



CORAL GARDEN GLASS BOTTOM BOAT

Kaneohe Bay
Educational Field Trip - Information Sheet

Cruise #1: South Bay Patch Reef Cruise

Depart pier for 10 minute cruise to patch reef including narration on the major points of interest (the Koolaus, Chinaman's Hat, Kapapa Island and the barrier reef, Mokapu peninsula, Ulupau Head, Coconut Island) and a brief description of each, i.e., Chinaman's Hat is a sea stack, Ulupau Head is a tuft cone, etc.

Arrive at the patch reef where we will drift over approximately 500 yards of reef. Narration will include descriptions of the various corals, sea cucumbers, sea urchins, algae, and reef fish. 20 minutes is spent on the reef.

Depart reef for a 5 to 10 minute spin around the bay which will include a plankton tow with a description of plankton in general, and the specifics on the plankton that are netted: a description of the Heeia fish pond and the operation of Hawaiian fish ponds in general.

Arrive at patch reef where viewing over the bow and sides is encouraged. A diver will go over the side and bring up bubble algae and any other reef animals that may be found. The stay on the reef will be approximately 10 minutes, and viewing may also be done through the glass boxes.

Depart reef for 10 minute ride back to the wharf during which the algae will be available for inspection. A description of the various animals to be found in the bubble algae (crabs, shrimps, sponges, tunicates, bryozoan, etc.), will be given and these animals may be inspected first hand.

Total time: Slightly less than one hour. (55-60 minutes)

Cruise #2: North and South Bay Comparative Patch Reef Cruise

Depart pier for a 25 minute ride to a patch reef in the north end of Kaneohe Bay. A complete narration on the history and geology of the bay and the Koolaus, a description of patch reefs, fringing reefs, reef flats and the barrier reef, and a description of major points of interest.

Arrive at the patch reef for a 20 minute viewing of a healthy coral reef with a description of the various corals and the reasons this patch reef is healthy in respect to the second reef we will visit.

Depart patch reef for 20 minute ride back to the south end of the bay with a plankton tow en route. Description of plankton in general and the specifics of the plankton netted will be given.

Arrive at the patch reef in the south end of the bay for a 20 minute view of reef that shows the effect of pollution. A description of the differences

between the healthy and an unhealthy reef will be given along with a description of the corals, algae, reef animals, and fish.

Depart reef for another plankton tow which can be compared with the results of the first plankton tow in order to show the effects of pollution. A history of the Heeia fish pond as well as a general description of Hawaiian fish ponds will be given for about 10 minutes.

Arrive at patch reef where viewing over the bow and sides is encouraged. A diver will go over the side and bring up bubble algae and any other reef animals that may be found. The stay on the reef will be approximately 15 minutes.

Depart reef for 10 minute ride back to the wharf during which the algae will be available for inspection. A description of the various animals to be found in the bubble algae (crabs, shrimps, sponges, tunicates, bryozoan, etc.) will be given and these animals may be inspected first hand.

Total time: 110-115 minutes

Cruise #3: Optional Programs

You design your own programs. We're flexible with all the parts of Cruises #1 & 2. The bay is a good location for exploring sandbars and coral reefs, Hawaiian weather, history, and geography; marine biology, etc.

1 hour cruise (55-60 minutes pier to pier)

2 hour cruise (110-115 minutes pier to pier)

General Information

1 - Boat Description - 49 passenger capacity - enclosed area for glass bottom viewing - outside deck with guard rails around the boat - 44 ft. long.

2 - Location - Heeia Kea Small Boat Harbor, Kaneohe. 3 miles North on Kam Hwy from the junction of LikeLike and Kam Hwy.

3 - Schedule - Arrangements available 7 days a week.

4 - Narration - We will provide the narration if you like or you can provide your own narration. A microphone is available with speakers inside and outside of the boat.

5 - Insurance - The boat is fully insured by First Insurance of Hawaii.

6 - Payment - Checks or purchase orders should be made out to:

Kaneohe Bay Cruises Inc.
41-879 Laumilo St.
Waimanalo, Hi 96795

For further information call 247-0375

A Plankton Key

SOME READILY OBSERVED PLANKTON FROM DAYTIME SURFACE TOWS MADE OFF WAIKIKI USING A 50.2 CM DIAMETER, 243-MICRON MESH NET.

INTRODUCTION. This very limited key is intended as an introductory aid for the novice student who makes a first examination of live plankton aboard ship on a BML cruise. Most of the work will be done on deck using the 30X "pocket lens." The key is equally useful for any post-cruise examination of the preserved plankton done in the school laboratory.

Most of the plankters described here have been selected on the basis of their frequency of occurrence or large numbers, or because their unique form or color make them stand out. Many interesting and important species are not included because of their small size, since most students will have only limited opportunity to use magnifications above 30X. It is important also to recognize that what plankters are captured in these tows are determined by many factors such as: a) where the tow was taken, b) the time of day, c) the season, d) the depth at which the tow was made, and e) the dimensions of the net, including the size of the mesh. Even the speed at which the net was towed can influence the catch.

Descriptions of the specimens are from actual observations, and the sizes given are approximations in most instances. It should be noted particularly that these figures can be misleading because they may be interpreted as an average size. For instance, the planktonic mollusc Carinaria is known to reach a length of at least 30 cm, but the Waikiki specimens examined thus far are less than 1 cm.

PHYLUM PROTOZOA.

1) Class Mastigophora; Noctiluca sp.

This animal is shaped like a balloon, but is more often found very crumbled as though it had been popped. There is a long cord-like flagellum that is characteristic of the animal. The name means "night light," as it is quite luminescent. It is not common in our tows. Specimens may reach a diameter of 5 mm.

2) Class Dinoflagellata; Ceratium sp.

This armored animal may occur in short chains of two or three organisms. The curved spines (called horns) may be broken. There are almost always a few in each tow. Since they are heavy animals they sink to the bottom of the specimen dish very quickly. The average length is about 0.1 mm.

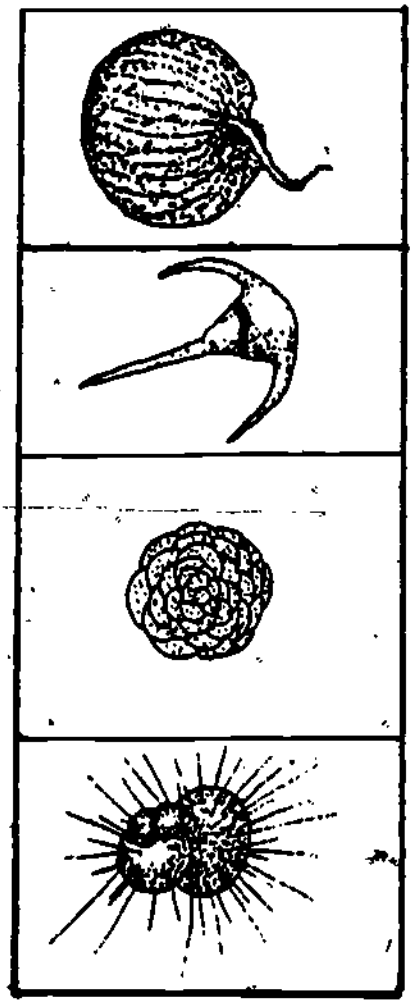
3) Class Sarcodina

a) Cymbaloporetta sp.

Skeletons of these animals are called "tests." This one is a somewhat bubbly looking disc that resembles a many-petalled flower head. Each "petal" is a separate chamber that has many tiny holes, called foramen, permitting the animal to have contact with the water. They may be very clear, or slightly tan. Not common, and quite small, but striking to see.

b) Globigerina sp.

There are always some of these in the tows. They sink to the bottom of the container and become stuck to other plankton, but are easily spotted by the orange, pink, or rose color of the living animal, and by the distinctive shape. Some are completely covered by long, needle-like projections, while others may have very few. The test consists of many rounded chambers of differing sizes. One species is a single large, hollow sphere, sometimes mistaken for a fish egg or an eye.



UNIVERSITY OF HAWAII
BLUE-WATER MARINE LAB

c) Sphaerozoum sp.

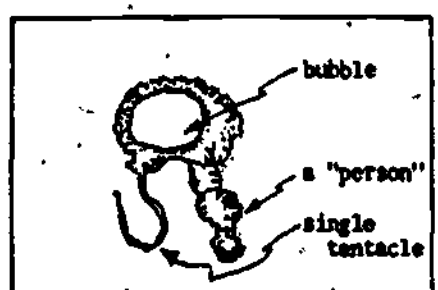
This large, colonial radiolarian animal is often numerous in tows. The colony may be round or sausage-shaped, or oval. Individual radiolaria appear like dots in the gelatinous mass which becomes fragile shortly after capture. A few specimens have been 25 mm in diameter, but most are about 4 mm across.

PHYLUM CNIDARIA (COELENTERATA).

1) Class Hydrozoa

a) Order Siphonophora

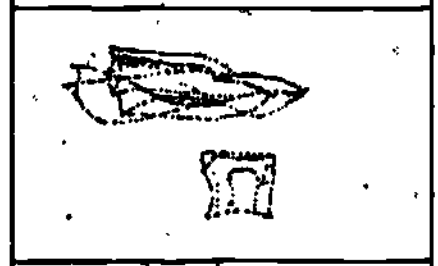
i) "Portuguese Man o' War"



A very young specimen

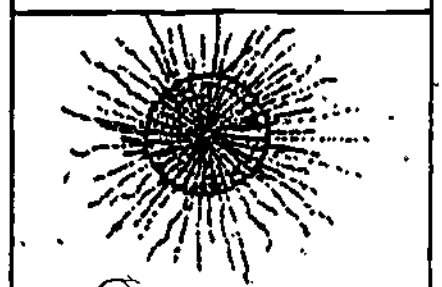
This "animal" is really a colony of animals which lives in the neuston, better known as the "Portuguese Man o' War." Very young colonies are found at times, recognizable by the bubble float which is small and round, and by the bluish-lavender of the surrounding tissues. There may be one or two small, flask-like "persons" (also called zoids) suspended below the bubble float. The tentacles may be missing as they are quite delicate. The float may be as large as 30-40 mm long for these young colonies. These animals possess stinging cells, known as nematocysts and often wash up on the beach.

ii) Siphonophora with clear, rigid components.



One common species is a clear, bullet-shaped animal having a deep notch cut into the wide posterior end. Another is also bullet-shaped but has curving ridges running from the sharp, pointed anterior end to the posterior. A third animal looks much like a cube with faintly crinkled edges. The bullet-shaped animals reach a length of 50 mm, and the cube-shaped animals may reach 25 mm.

iii) Porpita pacifica



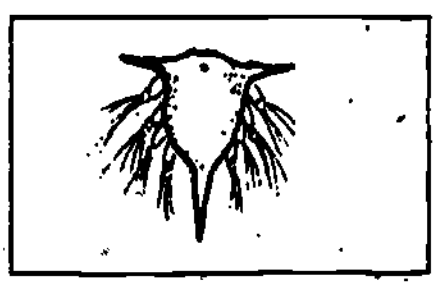
This flat, disc-shaped animal colony has many small flask-like "persons" (or zoids) attached to the underside of the disc, and numerous tentacles of differing lengths that may dangle from the edge, or spread out over the surface of the water like rays. The colony floats on the surface. Colors are a bluish-lavender with a faint green tinge. It is seldom seen. Although related to the Portuguese Man o' War, it is not known to harm people with its stinging cells. The disc may be to 30 mm in diameter.

2) Class Scyphozoa (jellyfish) and Class Hydrozoa (medusa)

Small, unidentified jellyfish-shaped creatures may be fairly common in some tows. The body (or "bell") is usually clear, but may be torn or collapsed. Tentacles may or may not be present. They might be true jellyfish or the medusa (meroplankton) stage of some hydroid animals. The bell may be 30 mm in diameter.

PHYLUM ARTHROPODA-Class Crustacea

1) Larval Forms (Meroplankton)



a) Nauplii

These are small and flat, but the characteristic triangular shape and many tiny legs make them easy to spot. They seem to settle to the bottom of a container rather quickly. There are either many or none in a tow. This is a characteristic reproductive stage of many crustacea including copepods, euphausiids, penacid shrimp and barnacles. Most specimens are about 0.5 mm long.

b) Crab larva ("zoea")

These very young crabs are called "zoea" and are frequently present in fairly large numbers. They move about by flexing their long, tail-like abdomens. The upper body region bears two stiff spines, one pointing forwards, the other backwards. Zoea eyes are large, often appearing shiny red or blue. One species has spines totaling 30 mm or more, and are banded red and white. Body length of most specimens is 1-3 mm.

c) Older larval crab ("megalops")

Older crab larvae are termed "crab megalops," or the "big-eye" stage of growth. These look very much like a miniature crab except for the abdomen, which is still extended like a short stubby tail. Their tiny legs and claws break off very easily. They are never found in large numbers. A large specimen may reach 5 mm across the carapace (body shell).

d) Mantis shrimp larva ("alima")

The larval stages of the mantis shrimp (also called "squilla") are known as "alima" larvae and are easily recognized by the characteristic shape of the claws that give the animal its name. Most of the body is covered by a flat, rectangular carapace that is quite broad and has two sharp spines projecting from the posterior corners. The abdomen terminates in a broad "tail." They are not uncommon. Young larvae may be 5 mm long.

2) Holoplankton

a) Copepods

i) Calanus sp.

These are robust copepods with long antennae, which are often held at right angles to the body. They are present in very large numbers in some tows, and quite common in most. Sometimes they are a bright blue. There are smaller species that may be red or brown. The larger specimens may be up to 4 mm long.

ii) Cyclops sp.

This small copepod is most easily recognized by the single red "eye" in the center of the head region, and the presence of two egg sacs (one on each side of the tail) that are almost always present in females. It may reach a length of 1.5 mm.

iii) Sapphirina sp.

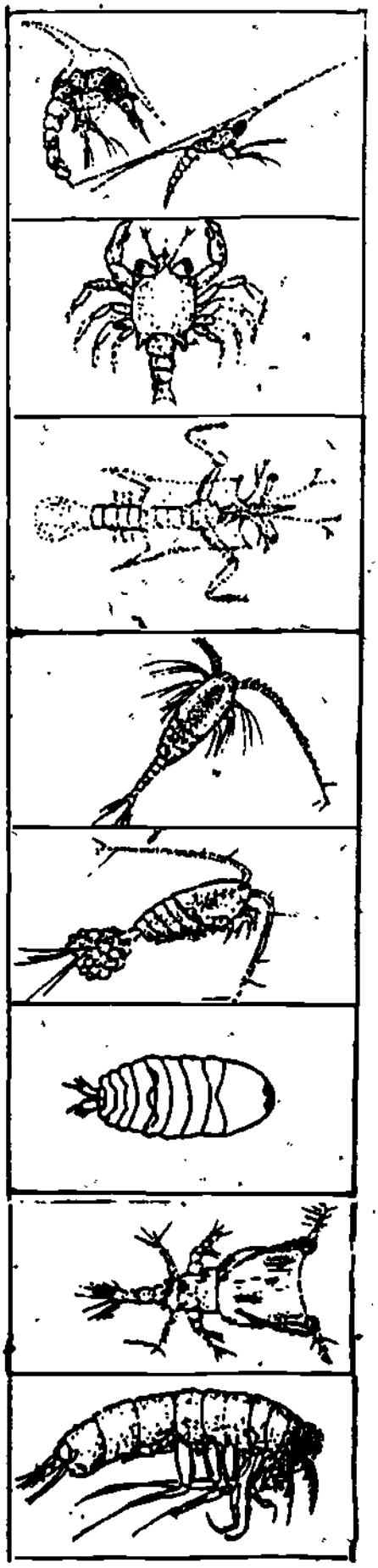
This large, very flat and broad copepod is most noticeable for its vivid iridescence. It is known locally as the "psychedelic copepod." Sapphirina is never abundant in tows. It is up to 2 mm long. The iridescence changes from brilliant blues to red after they have been caught.

iv) Coplilia sp.

These copepod forms have wide, flat, rectangular bodies that are crystal clear, since it is almost always the molt, or abandoned shell, that is observed. They are not common. They may be to 3 mm long.

b) Hyperiid Amphipods

These amphipod crustaceans have laterally compressed bodies so they are always seen from the side view. They are very heavy, have long slender legs and compound eyes so large they seem to cover the entire head region. They are not common. The backs of the animals are strongly curved. They may be up to 2 mm long.



A Plankton Key

c) Mysis sp.

This slender-bodied animal is frequently bent at such a sharp angle that the carapace appears barely attached to the abdomen. Even if not bent, it is easy to lift the carapace from the body with a needle. Legs are short, slender, and crowded to the front of the animal. They may reach 0.5 mm in length. The carapace acts as a brood chamber for young, and this group of animals are known as "opossum shrimps."

d) Class Decapoda; Lucifer sp.

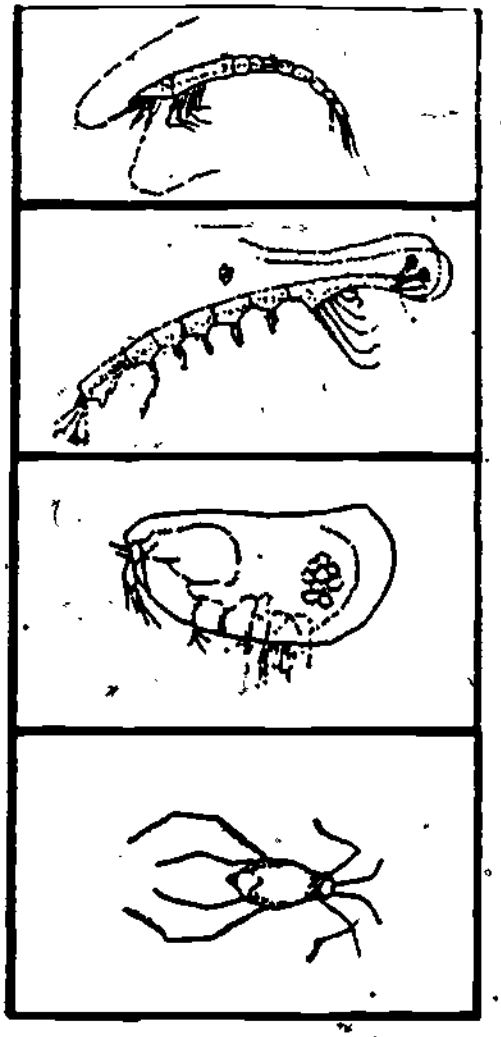
This is the only decapod animal that spends its entire life in the plankton. It is long, flat, and very thin. Large compound eyes are set on long stalks and are easily broken off. Antennae are long and flexible; the legs are short. They are very common in some tows. The name refers to the clarity of the body tissue rather than to any relationship with the devil. They may reach 10 mm in length.

e) Class Ostracoda

Until one sees the tiny legs, this animal is often mistaken for a mollusc, perhaps because the animal is encased in a bean-shaped shell that is hinged at the top. Living specimens may show their pink, orange, or red color through the shell. One species has a heavy shell that is dark brown. Shells may be smooth and clear, or mottled, or heavily embossed with raised designs like a peanut shell. They are not usually found in any great numbers. The shell may be to 5 mm long.

f) Class Insecta; Halobates sp.

This is the only oceanic insect known, and is found the world over. It is a surface dweller related to the "water strider." The body is rather small and tear-shaped, but the legs are quite long and slender. They occur in great numbers on the sea surface but are seldom captured in our plankton nets because we are too close to shore and because they are very swift. Hawaiian specimens may be blue-gray, metallic blue, or even dark brown. The body is about 5 mm long, but total animal length may be 30 mm or more.



PHYLUM MOLLUSCA

1) Class Gastropoda

a) Heteropods

i) Carinaria sp.

This mollusc has a long, thick, soft body that is transparent. The fleshy fin of the animal has a sucker in it, and the animal may stay just under the surface film in what we would consider an upside-down position most of the time. They are not common but some tows may have several specimens. There is a tiny conical shell on the back of the animal that is very difficult to see. Animals in our tows may be up to 40 mm in length.

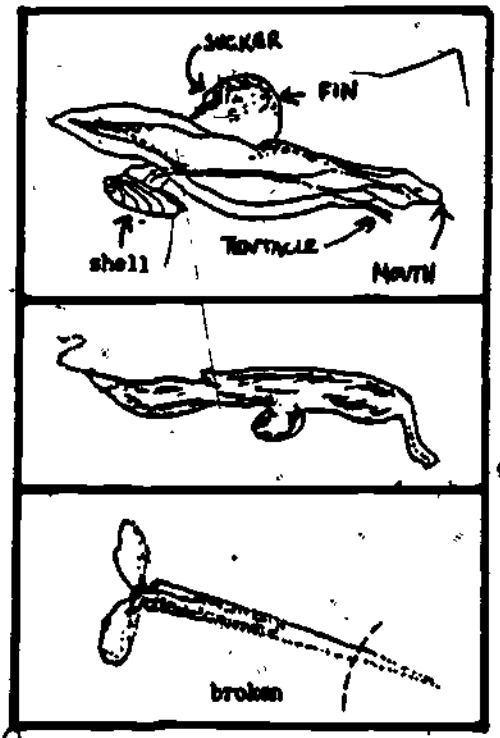
ii) Pterotrachea sp.

This large, thick, long, and colorless animal is a shell-less mollusc. There is a flap of tissue on the ventral (bottom) side that acts as a keel, and the head end of the body is extended into a long tube. Tiny eyes shine a vivid blue. There are rarely more than three or four in a tow. May be up to 100 mm long.

b) Pteropods (pteropod = wing foot)

i) Cresis sp.

This long, slender, tapering shell is fragile and may have the tip broken off. The young are transparent, but older shells are opaque. The animal moves by means of the two ear-like flaps. A few may be in any tow, seldom numerous. May be up to 5 mm long.



ii) Euclio sp.

These transparent shells have a strong triangular shape and a wide opening. Older shells are translucent, younger ones are transparent. Never common in tows. They may be up to 0.5 mm long.

iii) Spiratella sp.

These small, periwinkle-shaped shells may be very common in tows. Some have delicate raised checkerboard designs; others may be ridged. Size ranges to 0.2 mm.

c) Glaucus sp. (nudibranch)

This unlikely mollusc is seldom found except when strong onshore winds are blowing. The animal is a dark metallic blue on the dorsal side, and silvery gray below. The projections (papillae) are used for movement and as a flotation device. Very young specimens may be quite plump with stubby papillae. They have been found up to 25 mm in length.

d) Janthina sp.

This fragile globular shell occurs in fair numbers when strong winds have been blowing onshore. The shell is lavender to purple, as is the animal. They are closely associated with the Portuguese Man o' War (their food). There is frequently a raft of bubbles attached to the animal, which is their flotation device. Shell size ranges up to 0.5 mm in our tows.

e) Larvae

i) Echinospira larva; Velutina sp.

An uncommon, but exciting find is a large gelatinous globe that may be smooth or have scalloped ridges. There is an embryo mollusc inside. Gentle pressure will extrude the mollusc. Some of these embryo "cases" may be empty. The adult mollusc has chewed the mass out of a tunicate animal and deposited a single egg inside. These cases may be 1 mm in diameter.

ii) Veliger larva

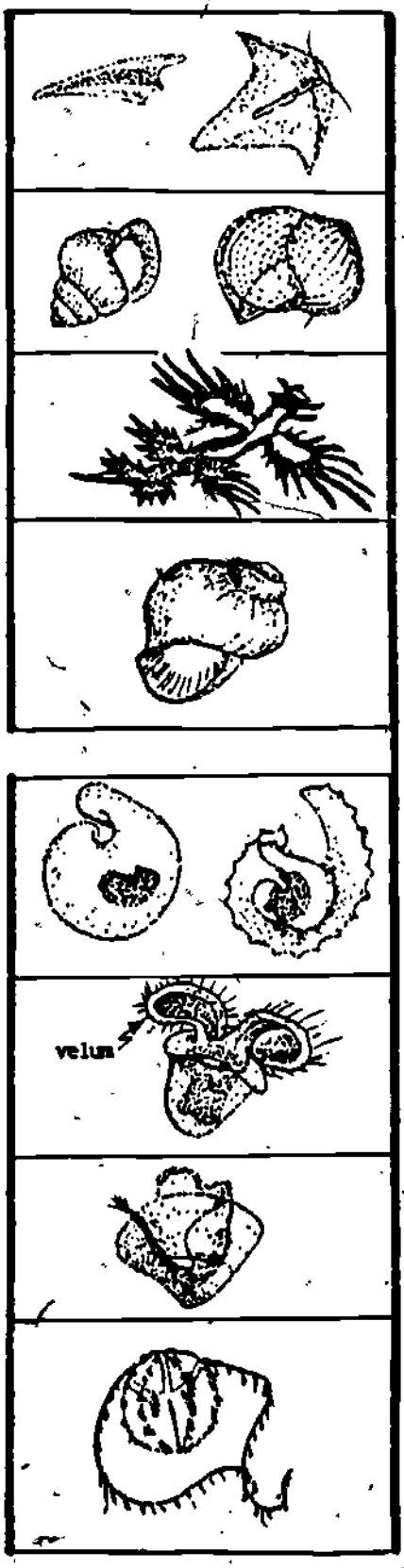
The very young stages of many gastropod animals have crystal clear shells seemingly too small to accommodate the larva. Movement is accomplished by means of two flaps (the velum) that have rapidly moving flagella along the edges. Shells may be to 0.6 mm in width. These larval stages are called "veligers."

iii) Class Pelecypoda; bivalve larva

These tiny clam-like shells may be crystal clear, or tan or golden in color. They are often present in our tows, sometimes in large numbers. They may be up to 0.5 mm in width.

PHYLUM CTENOPHORA (THE COMB JELLIES); Pleurobrachia sp.

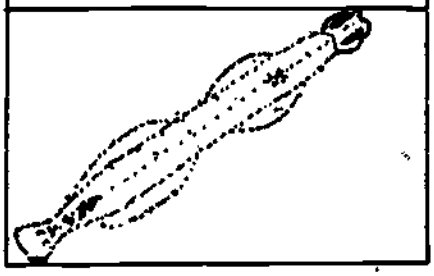
These little round animals are also known as "sea walnuts" or "sea gooseberries." They may be very common, and are first noticed by the iridescent flash of tiny rows of rapidly beating flagella that range down the sides of the body. The trailing tentacles are sticky, trap food, and accumulate debris. Ctenophores bioluminesce. Body size reaches 20 mm in diameter.



Phylum Ectoprocta (Phylum Bryozoa); Cyphonautes larva

These are not common, but are easily identified by the flat, triangular, crystal clear shell. If the living animal is not disturbed the flagella can be seen protruding from the corners. This larval stage is called a "Cyphonautes" larva and they are usually 0.5 mm or less. The term "bryozoa" is a very common but is no longer considered the proper name for this group.

Phylum Chaetognastha (The Arrow Worms); Sagitta sp.

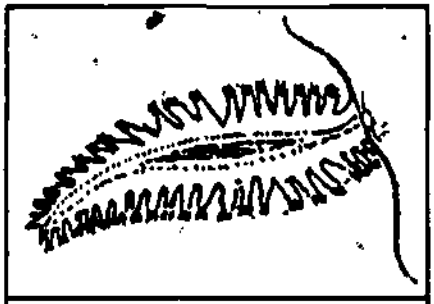


These long, slender animals are often found in unbelievable numbers, especially in tows taken near sewer outfalls or in nutrient-rich waters like Kaneohe Bay. The fins are hard to see, but the golden curved bristles at each side of the mouth are not. The bodies are very clear, rarely showing any hint of internal organs or of ingested food. The animal is usually about 5 mm long, but at times may range up to 10-15 mm.

Phylum Annelida

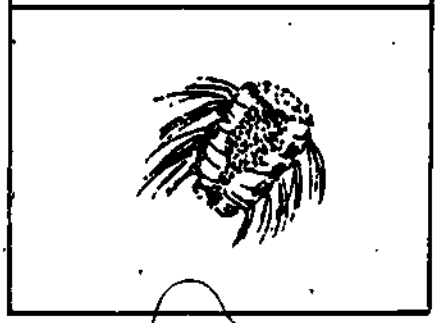
1) Class Polychaeta

a) Tomopteris sp.



This species of annelid worm is the only one that spends its entire life in the plankton. It is not common in our tows, but is instantly recognizable because of its unusual shape, and by the graceful undulations of the body as it swims through the water. Specimens may reach 15-25 mm in length.

b) Polychaete worm larva

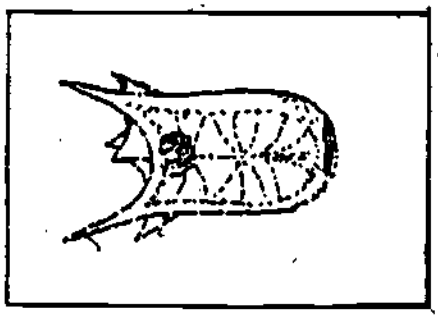


All other annelid worms spend their adult lives in or on the bottom, but the larval stages are not infrequent in plankton tows. The earliest stages of some resemble a globe completely enveloped in long, curving golden bristles. Older stages of growth show the distinct head with two or more pairs of eyes that are quite noticeable, and will have a varying number of body segments (depending on the age). Each segment has bundles of bristles (setae) on each side. Sometimes, pieces of worms will be found in the sample. The larva may reach a length of 3 mm in our tows. Annelid worms are also know as "bristle worms," polychaetes, or errant polychaetes.

Phylum Tunicata

1) Thaliacea

a) Salpa sp.



This somewhat tube-shaped animal is quite clear, and may be first noticed by spotting the lei-shaped stolon at the posterior end. There are also four short tapering tentacles, as well as a criss-cross design created by the body muscles which will help you recognize salps. These salps are sometimes very abundant and may reach a length of 20-30 mm in our tows.

b) Doliolid

These salps resemble clear, empty barrels that are open at both ends. There are faintly visible encircling muscle bands. They often appear quite shriveled, and may be rather common in some tows. They are up to 20 mm long.

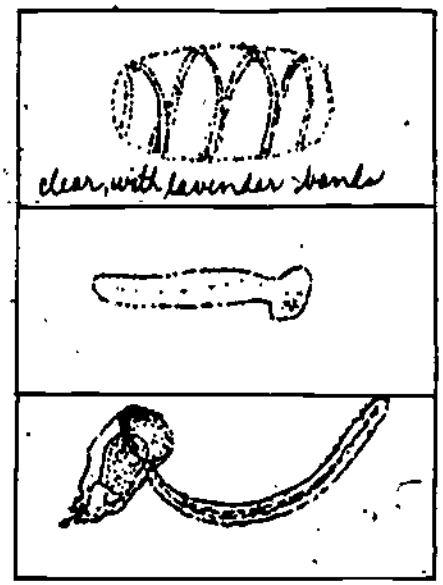
2) Larvacea

a) Fritillaria sp.

The dense oval portion of this animal is actually the entire body, except for the tail. These are usually found in abundance in a tow, or not at all. The tail region may appear slightly iridescent. They may reach an overall length of 2 mm.

b) Oikopleura sp.

The entire body of this small animal is contained within the dense oval region that resembles a head. The flattened tail region is frequently iridescent. They are almost always found in some numbers in a tow. They are usually 4 mm or less in length.



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FIELD TRIP II - CAMPBELL PARK

FIELD TRIP II - CAMPBELL PARK

Instructional Goals

Students will demonstrate an appreciation for the interdependence of living things in the closed earth system.

When faced with decisions concerning the use of terrestrial and extraterestrial resources, students will select practices developed in recognition of present and future environmental and human needs.

Instructional Objectives

Explain what an environmental impact statement is and how it is used.	SS, Sc
Discuss the physical features of the coastal zone areas of Hawaii.	SS, Sc, HS
Discuss the change in flora and fauna from the seaward limit of the coastal zone to the landward limit.	Sc
Discuss the economic value of coral.	SS, Sc, M, C

Performance Expectations

Predicts the effects social, political, and economic changes would have on the environment.

Uses a variety of resources to gain information on environmental matters.

Conducts simple investigations to gain first-hand information on environmental matters.

Describes instruments or methods that can be used to gain information about environments or change an environment for a desired result.

Integrates information gained from resources with information gained through direct experience to develop understanding of environmental matters.

Explains the effects of environmental changes on recreational opportunities.

Describes the natural resources needed by various industries and relates the locations of those industries to available resources.

Describes the impact of various industries on the environment.

Identifies state and federal agencies primarily concerned with environmental management or control.

Cites examples of negative and positive ways human beings can change the environment.

Compares the aesthetic value of maintaining natural environments with the need for housing, improved transportation, and increased employment opportunities.

Essential Competencies

Reach reasoned solutions to commonly encountered problems.

Distinguish fact from opinion in TV and radio news broadcasts, advertising, newspaper and magazine articles, and public speeches.

Use resources for independence learning.

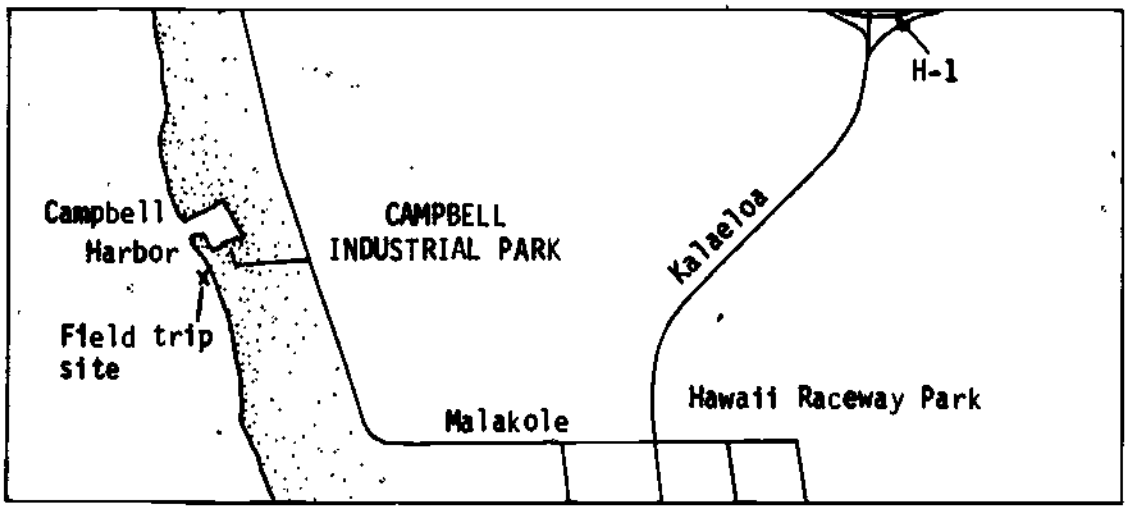
Identify the training, skill and background requirements of at least one occupation in which the student is interested.

Demonstrate knowledge of the basic structure and functions of national, state, and local governments.

TOPICS DISCUSSED:

1. ENVIRONMENTAL IMPACT STATEMENTS (EIS)
2. COMPOSITION OF CORAL REEFS AND BEACHROCK.
3. ZONATION OF MARINE INVERTEBRATES.
4. CEMENT - ITS ORIGIN AND MANUFACTURE.

CAMPBELL PARK FIELD TRIP SITE



To reach this site from the Honolulu side of the island, take the H-1 freeway towards Waianae. Take the Campbell Industrial Park, Exit 1 turnoff. As you come to the top of the turnoff ramp you will be on a bridge over the freeway below. Begin a mileage check at this point. Go straight down the road 1.5 miles, then turn right on Malakole Road. Hawaii Raceway Park is on your left just before the turn. Follow Malakole Road for 1.4 miles and turn left. As you turn left there will be large white storage tanks to your right. Follow this road a short

distance until it ends by a quonset hut and an elevated propane tank. Park here, and take a path leading off to the left. A short walk takes you over a small rise and brings you to the lovely beach which is the field trip site.

Safety: 1) The beach rock is covered with algae and is very slippery. Caution students to walk carefully. 2) Be careful of the waves. Never turn your back to the sea.

Barber's Point Beach Park Sanitary Facilities

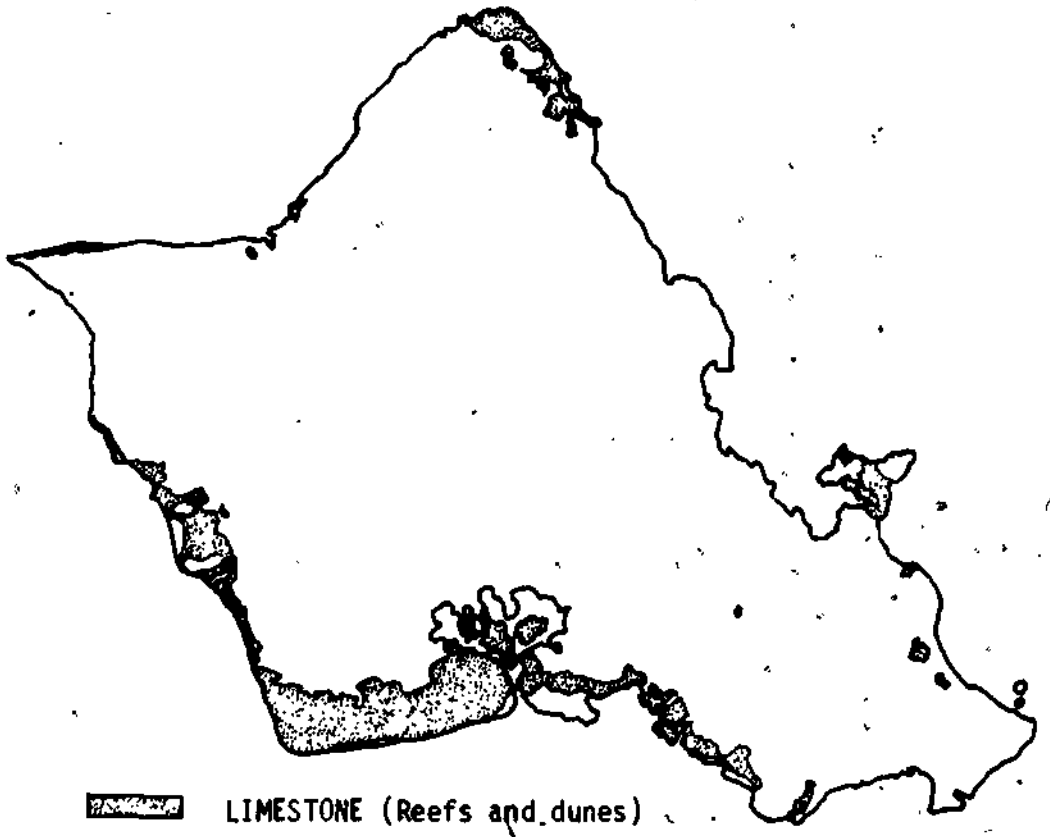
This site does not have any sanitary facilities, although nearby Barber's Point Beach Park has bathrooms, showers and drinking fountains. After the field trip you may want to stop at Barber's Point Beach Park. As you leave the field trip site and go back along Malakole Road, you'll see a sign indicating the turnoff to the park. Follow it 1.1 miles until you come to an intersection with a building with a "Carter Co., Inc." sign and an American flag on a flagpole in front. Turn right, and this road takes you directly to the park.

INTRODUCTION

Oahu has great areas of fossil reef that were formed when the surrounding seas were higher and warmer. Conditions like these may have occurred during an inter-glacial period, a time when the polar ice caps were melting due to a warmer climate worldwide, and the seas consequently contained a greater volume of water. When the glacial periods returned, and water was withdrawn from the sea to re-form the polar ice caps, these reefs were left high and dry.

The largest fossil reef area on Oahu is the Ewa Plain. This area contains Campbell Industrial Park, a small barge harbor, and is the site of a proposed 77 acre deep draft harbor. The field trip site is on the beach, Diamond Head of the barge harbor.

Pre-field trip activities will discuss Environmental Impact Statements, using the one for the proposed deep draft harbor as an example. On-site activities include examination of the structure of a coral reef, a beach rock bench, and the zonation of marine invertebrates, as well as a look at the area to be affected by the proposed deep draft harbor.



LIMESTONE (Reefs and dunes)

PHYSICAL DESCRIPTION

Under the topsoil and sugarcane that covers the Ewa Plain, lies a

fossil coral-algae reef that extends 20.8 km along the shore from Pearl Harbor to Kahe Point, and 4 to 4.8 km inland at the wider points, covering approximately 64 square km. This fossil reef and a similar one in Lualualei Valley are presently limestone quarry sites.. Limestone is used in the manufacture of cement.

The field trip site lies along the ocean, Diamond Head of the entrance channel to the barge harbor. The sloping beach is made primarily of calcareous sand. A "beach rock" bench is a prominent feature at the seaward edge of the shore, while large chunks of fossil reef lie exposed along the beach. Broken pieces of the beach rock also lie exposed along the beach.

This site has a westerly exposure, and is generally calm. It should not be used if the surf is high on this side of the island. If the marine life is to be studied along with the fossil reef, a day should be chosen when the maximum low tide is zero feet or less. If only the fossil reef is to be studied, a low tide of one foot or less is adequate.

Legend:

A is Beach Rock Bench

B is Chunks of Fossil Reef

BIOLOGICAL DESCRIPTION

The beach rock bench provides a hard substratum for the attachment of marine invertebrates. This bench can be divided into 3 habitat zones. While the bench is pitted with small depressions, there are no large tidepools or rocks to offer protection to the less hardy species, and the animals living here are all well adapted to a rigorous life-style. This bench is relatively narrow, and the zonation of different species across it is striking.

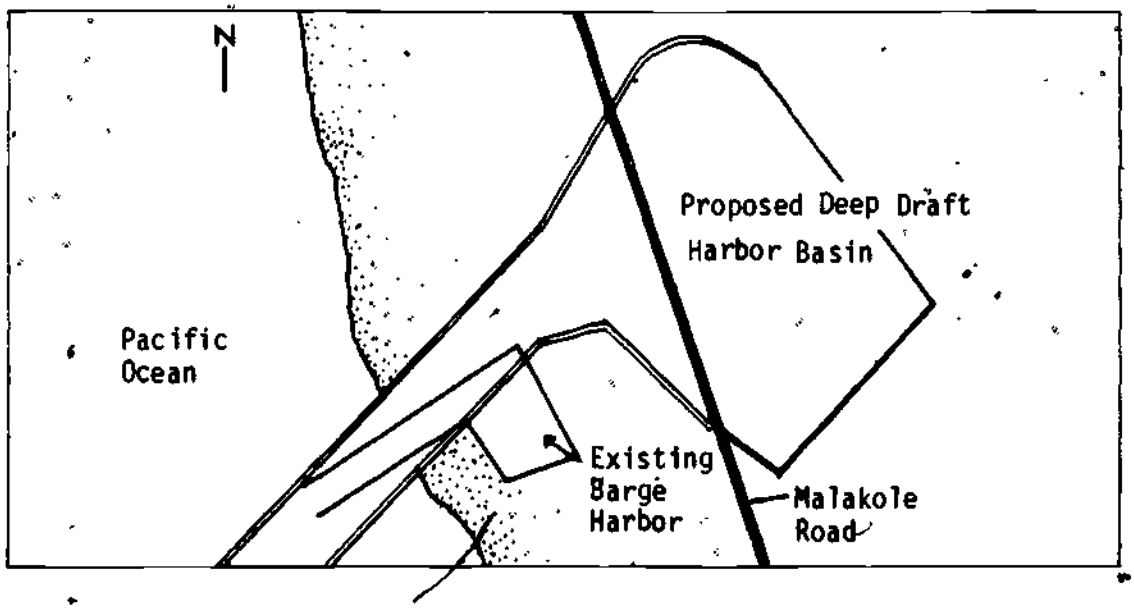
TOPIC 1: ENVIRONMENTAL IMPACT STATEMENT

This section includes a summary of the course of events surrounding the acceptance of the EIS for a proposed Barber's Point Deep Draft Harbor. It explains by example what an EIS is and how it is useful. Activities include discussion of this example, an on-site inspection of the area to be affected, and the development of an EIS as a class-designed project.

> An environmental impact statement, or EIS, is a written report which describes what may happen to the environment should a project be carried out. For example, an EIS for a new power plant would discuss air and water pollution, effects on marine life, impact on fuel resources, economic and social benefits/costs, and long range effects on land use in the surrounding area.
> (From EIS Handbook: A guide to Hawaii's requirements and process, by Ray Tabata, UH Sea Grant College Program)

Campbell Industrial Park is a planned industrial area which provides an alternative to the crowded and congested conditions of Honolulu. Its location, 22 miles from Honolulu on the flat Ewa Plain, is a good setting

for an industrial park. The coral ground provides good grading and drainage for building. It also has an excellent load-bearing capacity. Smoke, dust and other odors from the various industries are carried out to sea by the tradewinds.



The park has a small barge harbor which is proposed to be expanded into the Barber's Point Deep Draft Harbor. Controversy surrounded the proposal for this harbor. Economists pointed out that the site would satisfy the economics of today, and the future needs for container cargo facilities. The site is also appropriate in view of the Hawaii State government's plan of a "directed growth policy" toward leeward Oahu. However, opposition to the harbor has been expressed due to the potential adverse effects on local plants, animals and historical sites.

Project authorization falls under Section 301 of the River and Harbor Act. The authorizing document was published on February 25, 1965 and provided the justification for the project. The Army Corps of Engineers did model studies in 1967-68. Through these studies it was decided that

a trapexoidal shaped, 38 ft. deep, 77 acre basin would be the best layout for the harbor. Since almost ten years had elapsed since the original studies, new studies were required to re-evaluate the project and to reaffirm the need for the harbor. Emphasis in these later studies was placed on present and projected navigational, economic, social and environmental conditions. A draft Environmental Impact Statement was prepared and submitted on April 12, 1976. With its acceptance, detail design studies were begun. The final Environmental Impact Statement with comments was completed December 7, 1976.

The EIS contains a brief project description which includes maps of the area with and without the proposed project. The site is described as a dry coastal area located on an emerged ancient coral-algae reef. Water quality, chemical analysis and bottom characteristics were all surveyed. A botanical survey revealed that the area contained the usual dry land vegetation with one significant addition. A plant believed to be extinct, Euphorbia skottsbergii var kalaelona Sherff, was found on the edge of the federal harbor limits in the area to be developed into shore-side facilities and also on the privately owned land adjacent to the harbor site. Since its discovery it has been proposed for placement on the endangered species list. If accepted, it will be one of the few plants in the U.S, to be legally declared endangered.

Wildlife surveys turned up only feral dogs and cats, mongoose, house mice, and rats. The most prevalent species of birds were the barred and spotted dove, and, with the exception of the Black Crowned Night Heron, all identified species were introduced rather than native birds. The area was found not to be a major nesting ground for any particular species.

The draft EIS and final comments were published in July, 1976. Many federal, city and county, and private agencies reviewed and commented on the EIS. Most felt the draft was adequate. Negative comments centered around the flushing characteristics of the harbor, plans for disposal of the dredged reef material, destruction of archeological sites and destruction of habitat for the plant Euphorbia skottsbergii var. kalaeloana Sherff.

A supplement to the EIS was prepared in conjunction with post-authorization detail design studies. These studies dealt with some of the concerns that had been raised. A Cultural Resource Study was done, and 27 sites were excavated. Not only were significant artifacts found, but large quantities of bird bones were also found. The bones are from extinct species of birds including a flightless goose, an eagle, the largest finch-beaked birds from Hawaii, a raven, long-legged owl and a flightless rail. The study found that the area is archeologically important and eligible for nomination to the National Register of Historic Places. Work in this regard is being co-ordinated with the State Historic Preservation Office. All sites affected by the harbor will be salvaged before construction begins. None of the sites recommended for further studies are directly affected by the harbor, but 11 sites are very close to the harbor limits. These sites will be salvaged before construction. The state will be responsible for further salvaging and recovery of sites that will be affected by construction of shoreside facilities.

Results of additional botanical studies recommended the inclusion E. skottsbergii var. kalaeloana Sherff on the endangered species list. The state would have to insure adequate protection of the plant with a

buffer zone added to assure protection. The area would preferably be one where the plant is growing naturally or, as an alternative, would be an area with suitable conditions to assure continued survival of the species. In addition to the reconnaissance study, a recovery team was sent into area to learn as much as possible about the plant, its distribution and propagation.

Consideration of potential flushing problems and solutions were also part of the detail design studies. These problems were discussed with the Department of Fish and Game and other wildlife agencies. Concern centered around circulation, flushing and potential eutrophication., It was concluded that the residence time, the average time a parcel of water spends in the harbor, of the deep draft harbor would be significantly greater than that of the existing barge harbor. Fresh water seepage from the groundwater lens into the harbor would increase the level of the nitrates in the water. This is a consequence of percolation into the groundwater of sugar cane irrigation tailwaters containing inorganic fertilizers. Phosphate, another nutrient present in the fertilizer, was not present in the ground water. If the two compounds were both seeping into the harbor, they would cause the level of algae growth to increase greatly and eutrophication might occur. Eutrophication is a process generally resulting from excessive increases in mineral and organic nutrients in the water. The net effect is a stimulation of algal growth. If flushing is poor, the algae accumulate and the oxygen demand resulting from decomposition and respiration at night reduces the dissolved oxygen in the water. This can seriously affect resident animal life and in extreme cases, like the Ala Wai Canal and occasionally Pearl Harbor

can cause fish kills. However, since the algal stimulation would require both nitrogen and phosphorus, and since the phosphate was not appearing in the ground water entering the harbor, it was determined that this would not occur, and that the excess nitrate would be flushed into the offshore water. However, it was determined that the water quality would deteriorate due to the increased flushing time which would permit an increase in the accumulated algal biomass in the water regardless of supplementary nutrient inputs. Turbidity of the water would likely increase, and normal harbor operations would stir silt from the bottom as well as contribute various petrochemicals and industrial wastes to the water.

The supplemental report also contained a Shoreside Facilities Development Plan. This preliminary report was submitted with the recommendation that the plans be dealt with in future separate documents.

The final EIS and Detail Design Studies were approved and construction of the harbor should begin shortly. The economic value of the harbor can not be overlooked. A considerable amount of time and effort has been spent assessing this value and finding adequate solutions to the concerns raised by many people. Archeological finds and the rare plant will be protected. Although the EIS process is long and involves some costs, the process insures that decisions affecting the environment will not be made solely on economic considerations, but will involve thoughful consideration of the environmental impacts.

State requests harbor land use change

With the approved shoreline management permit in hand for the proposed Barbers Point deep-draft harbor, State planners have requested the upzoning of agricultural land to the urban designation needed to begin the project.

The Department of Planning and Economic Development (DPED) filed the required petition with the State Land Use Commission in January. The petition involves 166 acres of agricultural district land surrounding the harbor site and represents a major step towards finalizing the State's plans for the $96.2 million harbor complex.

No hearing dates are yet slated for the land use petition, filed by DPED on behalf of the sponsoring Department of Transportation.

If the petition receives approval, the U.S. Army Corps of Engineers will undertake the initial task of dredging the harbor and stockpiling coral material at the project site, at an estimated cost of $43.2 million.

Federal funds will provide about $41.3 million with the remaining 4.4 percent of the cost for initial harbor dredging to be funded by the State.

The State will pay the entire cost of about $53 million for construction of harbor facilities. The projected year of completion is 2030.

Department of Transportation planners have spread the construction over three phases. The first runs from 1980 through 1994, when most of the major facilities will be in place, with improvements added in later phases.

The special management area (SMA) permit, also called a shoreline management permit, was granted by the Honolulu City Council in December. Some Honolulu planners, though, had objected to the project because of threats to two rare plants (*Euphorbia* and *Achyranthes* species).

Experts have not yet determined whether these plants could be transplanted successfully elsewhere, and Honolulu Department of Land Utilization officials recommended the denial of the permit on this basis.

Other points raised concerned the impact of the project on recreational boating in the Barbers Point area. A private boat ramp is now located in the present barge harbor at the proposed project site.

However, the petition for the land use change includes a section written to demonstrate how the project conforms to the objectives and policies of the Hawaii Coastal Zone Management Program:

- While experts investigate whether or not the rare plants can be relocated, the *Euphorbia* colonies will be fenced off from the surrounding harbor area. The *Achyranthes* plants will not be disrupted by the project, the petition states.
- The State will plan the construction of a public boat launching ramp and other park facilities, "if such proves practicable," the petition states.

Council members approved the SMA permit after deciding that the issue of transplanting the plants could be resolved in later planning stages.

About 300 acres of land was sold to the State by the Campbell Estate. The agreement of sale provides that the State will give the estate about 90 percent of the proceeds obtained by selling about 10.6 million cubic yards of coral dredged out of the harbor site.

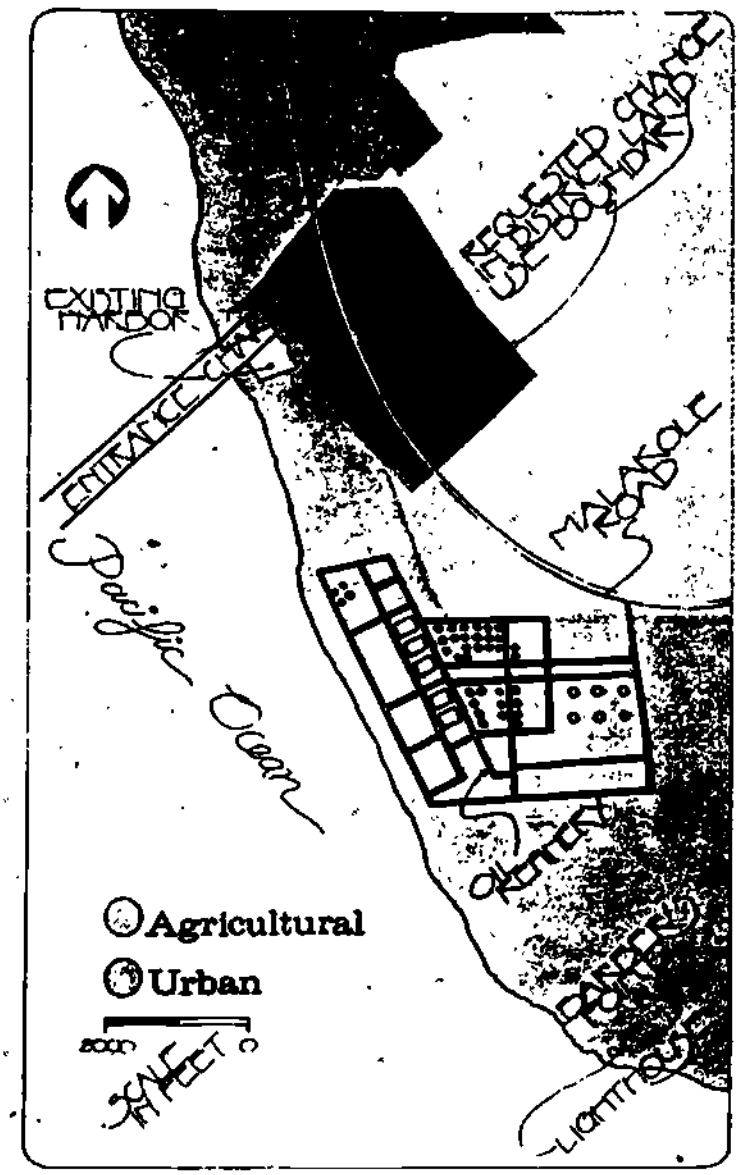
According to the project's environmental impact statement (EIS) prepared by the Department of Transportation last June, the effect of the harbor proposal must be viewed in the context of other related plans to urbanize the 'Ewa area:

- The Campbell Estate plans a 12,000-acre urban development to accompany the harbor, including a city center, 13 residential villages, a marina and a resort.
- Expansion is slated for the adjacent James Campbell Industrial Park, with the possible addition of 75 industrial firms and water transportation operations.

State planners have pointed to the need for a second major harbor facility to supplement the operations in Honolulu Harbor. Evaluations of alternate sites, including Pearl Harbor's West Loch and Kane'ohe Bay, have led them to conclude that Barbers Point is best suited for this purpose because of its proximity to Campbell Industrial Park.

State studies indicate a general shift in population to the 'Ewa area and an increase in cargo traffic to and from Hawai'i by the time the proposed harbor would be operating near the year 2000.

Harbor plays part in growth prospects



Barbers Point

Map indicates agricultural area that would be redesignated to urban should e panding State Land Use Commission petition be approved.

Activity I - Pre-field trip

Objective: To learn what an EIS is.

Procedure: Explain to the class what an EIS is by using the example provided. Questions that could be used to start a class discussion are:

1. Do you think an Environmental Impact Statement is useful? Why?
2. Many people fish and collect limu near the deep draft harbor site. Do you think harbor construction and operation will affect the marine life and therefore these people's collecting and fishing?
3. What are some of the economic benefits that will come from this proposed harbor?
4. Do you think the economic benefits are more important than the plants, animals and archeological sites affected? Why?

Activity II - On-site

Objective: To see the area affected by the proposed project.

Procedure: Make copies of the maps showing how large this project will be compared to the existing barge harbor, and give them to the students. Go to the existing harbor first to see its size, then walk down the road the way you drove in, past the large white tanks. When you reach the road turn left and walk about 24 meters until you see the opening to the quarry on your right. The quarry is where the harbor will be, and it will be about the same size. Limestone from this quarry is used to make cement.

Activity III - Post-field trip

Objective: To involve students in the EIS approval process.

Procedure: Obtain a copy of "EIS Handbook for Hawaii" by Richard J.

Scudder, available from the Office of Environmental Quality Control, 550 Halekauwila Street, Room 301, Honolulu, Hawaii 96813, telephone 548-6915.

After familiarizing the class with the EIS process, divide them into special interest groups, including developers, architects, economists, conservationists, biologists, fishermen or whatever seems appropriate. Have the developers design a project in an area that everyone is familiar with. Architects or artists can draw the layout of the project. Impartial consultants can write the EIS, comments from the community (classroom) will follow. Continuing in this way, as outlined in the pamphlet, you will go through the EIS process to either final acceptance or rejection.

Another alternative is to allow your class to become involved in the process by having them comment on an actual EIS. This can be done by first calling the Environmental Quality Commission at 548-6915 and having them put you on their mailing list. The EQC bulletin publishes a list of all the EIS's that are available for public review. Limited copies of each EIS are sometimes available at the EQC office for individual use. Their office is at 550 Halekauwila St., Room 301. They are also available at public libraries. The class may read, discuss, review and then submit comments on the EIS. Follow the guideline in the EIS Handbook. Class comments should be sent to the address specified on the individual EIS. By law the EIS preparer must respond to all comments. In this way your class will have actually participated in the governmental process concerning Environmental Impact Statements. This activity will be most beneficial if you comment on a proposed project in your own area.

TOPIC 2: COMPOSITION OF CORAL REEFS AND BEACH ROCK

This section includes a description of the processes involved in the formation of coral reefs and beach rock. The class should be familiarized with these processes before the field trip so that they have an idea of what to look for.

Coral Reef

The large chunks of fossil reef along the beach were removed during the excavation of the barge harbor. They offer an unparalleled opportunity to actually see a cross-section of a Hawaiian coral reef. However, certain background information is necessary in order to understand the story told in those reef rocks.

A living coral reef, one that is actively growing, is always found in shallow, sunlit water. Why is sunlight so important to corals? Corals that grow large and fast and build reefs contain many single-celled plants within their tissues. Scientists believe that the plants within the coral and the coral tissue exchange important substances which help them both grow better. When plants photosynthesize, they produce oxygen, sugars and starches. When animal tissue respires it gives off carbon dioxide and other organic compounds such as nitrogen. Plants can use animal waste products for growth, and animals can use plant products for their growth. When the plant lives within the tissues of the animal, these exchanges can take place internally, requiring less effort on the part of each. This type of mutually beneficial relationship is termed symbiosis. Since plants require sunlight for photosynthesis, the corals which contain plant cells in their tissues must live in shallow, sunlit waters if they are to derive benefit from these live-in plants.

Not all corals are symbiotic with plants. Those that are, are

called hermatypic (herm = support, typic = type) or "reef-building" corals. Those that do not contain symbiotic plants are called ahermatypic (a = not). They can live in deeper, darker, colder waters. The tiny plants within reef-building corals are single-celled algae, called zooxanthellae (zo-zan-THEL-ee; zoo = animal, xanth = yellow, ellae = little ones). An early biologist thought they were single celled animals rather than plants, and the name has not changed since that time. Zooxanthellae give much of the brown color to corals, although many corals have other pigments that can hide some or all of the brown.

Hermatypic, or reef building corals, are able to grow very fast (up to 10 cm per year for some branching forms), and this is important in the formation of a reef. These corals produce the hard calcium carbonate framework of the reef. As old corals die, new corals grow over the top, layer on layer. Coralline (hard, like coral) algae are marine plants which also secrete a hard, calcium carbonate skeleton. These help build the reef and cement it together, and they too grow layer by layer.

As wave action and storms attack the reef, pieces of corals and algae are broken off and ground into smaller particles. Marine animals die and their hard shells are ground up into smaller pieces. Other marine animals bore, eat, scrape and dissolve the reef framework. The breaking and wearing away of the reef produces sediments, loose sand, gravel and rubble, from the eroding framework. These sediments may be redeposited in the reef and cemented to it, may help build a sandy beach, or may be totally dissolved in the sea.

In combination, the framework of the corals, the bulk of the sediments, and the cementing action of the coralline algae, allow the reef to grow. It grows most vigorously where it receives the most wave

action and light and this is usually at the seaward edge of the reef. The seaward edge is also the place where the erosional forces are the greatest. A healthy reef will build faster than it is eroded away.

Beach Rock

Beach rock is believed to be formed when sand is in contact with cold ground water. This cold freshwater partially dissolves the calcium carbonate in the sand, which then resolidifies into a solid mass. Seepage of underground freshwater is plentiful at the proposed harbor site.

ACTIVITY IV - On-Site

Objective: To determine the composition of the coral reef and beach rock.

Procedure: Before the field trip students should make rigid wire frames for this activity. Use any stiff material, and shape it into squares 10 cm. on a side. Place this wire frame on a section of the exposed fossil reef. (The fossil reef chunks are on your right as you face the ocean). Try to recognize substances in the reef rock. The following descriptions should help:

1. Shells - usually broken pieces will be embedded in the reef rock.
2. Coral - large and small pieces of coral can be found in the rock. Coral is always porous, or dotted with holes. In some kinds of coral the holes are as big as the tip of a pencil. In others they are as fine as pumice rock. Coral may be white or gray. Once you have seen a few pieces of it, it is easy to recognize. Some corals are in chunks, others are in (6 mm) layers. This is because some corals are encrusting: thin and flat, following the contour of the rock. But even these thin layers have many little holes.

64

3. Coralline algae - step back from the rock a few paces, and look for evidence of a wavy or swirly pattern in the rock. Once you find this, look very closely at it. Can you see paper thin to 3 mm thick layers of a hard, white substance? If so, this is coralline algae. If the layers are ¼" thick and have holes, it's encrusting coral.

4. Other materials - deposited sand is easy to recognize, but mud layers are usually not. If you can't recognize what something is, just label it "other".

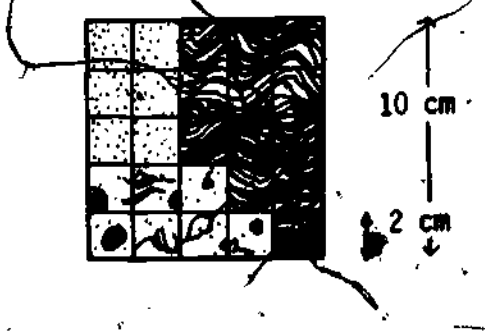
Everyone should have a chance to look for these different substances in the reef rock. As a student recognizes a material he/she could show it to the others, until everyone is familiar with the elements in reef rock. Do the same activity using the beach rock. (This is made of just sand.)

ACTIVITY V - On-Site

Objective: To quantify the material in reef rock.

Procedure: Before the field trip students should make 10 cm. square and string it with thread at 2 cm. intervals on both sides, to form a grid, On site, place this grid on the reef rock. Write down how many squares each material fills. Each square represents 4% of the total area. Students should then figure the percentage of each material in their sample so that the total comes to 100%.

Example



6 squares of coral = 24%
7 squares of shell = 28%
12 squares of coralline algae = 48%
100%

Either back in class or on-site, add up everyone's percentages of each basic material, then get an average percentage of each. What is this coral reef mostly made of (besides "other")? Could it be better called a coral-algae reef? Hawaii's reefs have a very large percentage of coralline algae in them, more than true tropical reefs which have a greater percentage of coral.

TOPIC 3: ZONATION OF MARINE INVERTEBRATES

This section includes an explanation of the major environmental factors responsible for the distribution of the marine invertebrates on the beach rock bench. A short identification of the common animals is included, and a transect is used to determine the zonation patterns.

Zonation

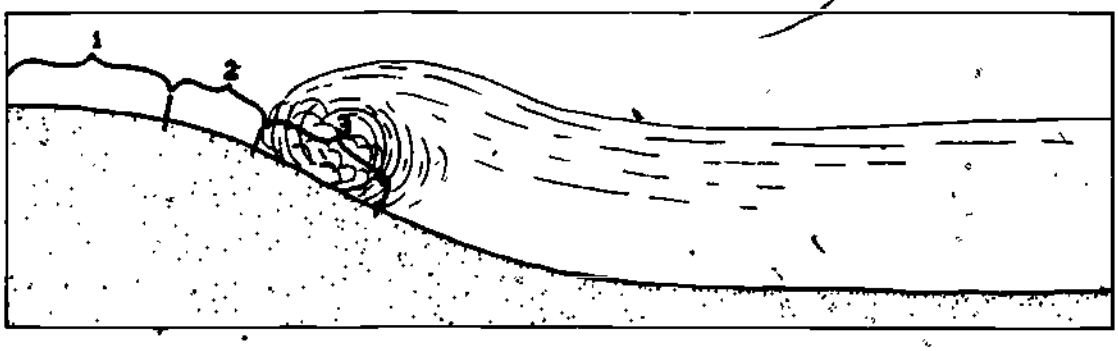
The beach rock forms a solid platform which begins at the high tide level and slopes towards the sea. It bears only small depressions over its surface. It is alternately covered and exposed by the daily tide changes and is also subjected to wave battering. Animals living there must be adapted to attach firmly to the hard substrate, so as to not be washed away. There is little in the way of crevices or tidepools to hide in, or rocks to hide under. Differences in animal populations across this bench can be attributed to varying environmental conditions rather than variation within the bench surface.

Zonation means that plants or animals will be found in predictable places based on environmental conditions. The beach rock bench at this field trip site is quite narrow, and yet can be divided into three major habitat zones on the basis of:

1. Amount of wave action each part of the bench receives;
2. Amount of time the different parts of the bench are exposed.

The three habitat zones are:

1. The upper intertidal (left exposed at low tide);
2. The intertidal (not left exposed as long as the upper intertidal and not subjected to as much wave battering as the subtidal);
3. The subtidal (exposed only between waves; subjected to constant wave battering).



Animals living in the upper intertidal are left high and dry during low tides, as only small depressions in the rock surface bear water. Strong sunlight causes the bench surface to heat up and the surface water to evaporate, increasing the salinity in the remaining water. Rain may cover the area with fresh water and rapidly decrease the salinity. When the tide is high, this area is washed by waves. Animals living here must be very adaptable. They must be able to withstand wide fluctuations in salinity and temperature and must be able to cling to the rock.

Animals living in the intertidal receive more wave action than those in the upper intertidal, but do not need to be so adaptable to changes in salinity and temperature.

Animals in the subtidal are constantly being battered by the waves.

They don't have to be as tolerant of salinity or temperature changes, but must be able to stand the constant beating without being broken or washed away.

Discuss these ideas with the class before the field trip. Perhaps they can think of other examples of zonation and the environmental factors causing it.

ACTIVITY VI - On-Site

Objective: To understand the concept of zonation by seeing an example of it.

Materials:

1. Three 15 meters (about 50') lengths of light rope (clothesline rope is good), weighted at each end, and marked with waterproof ink at 2 meter intervals.
2. One clipboard with paper and pencil for each group of three students.
3. One rigid frame ¼ meter on a side for each group of three students. (An expanded metal coathanger makes a good frame.)
4. One copy of animal identification material for each group.

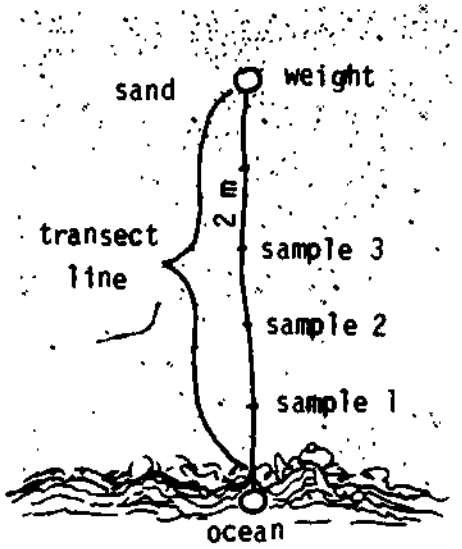
Procedure: First, CAUTION STUDENTS BEFORE THEY BEGIN to be very careful while working in the area near the waves. Supply each group with a wave spotter.

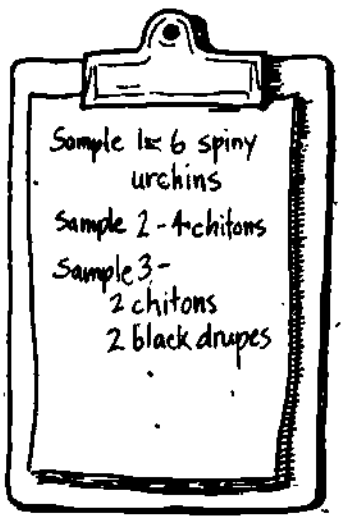
Place the transect lines across the beach rock bench. One end should be in the water, and one end on the sand. The line should be without slack so it cuts a straight line across the bench. Divide students into groups of three. Each team of three will do three areas along a transect line. Students should familiarize themselves with the animals they will

see by using the identification sheet provided in the appendix.

Instructions for students

1. Begin at the ocean end of the line. BE CAREFUL.
2. Place the wire square on the line so that the 2 meter mark is in the middle of the frame. Get as far down as you can towards the waves without endangering yourself.
3. On the paper, write "SAMPLE 1". Next to this write the number and kinds of animals that you counted in the square. Use the identification sheet if you don't know what the animals are.
4. Move mauka on the line, write "SAMPLE 2" for the next mark, place the square over the line with the mark in the middle and count and record the animals here. Do this for each mark on the line until you reach the sand.





DISCUSSION

After each group of three students has done a complete transect of the beach rock bench, have a discussion of what they saw. Did they see

examples of zonation? (Animals living on one part of the bench and not on other parts.) How wide was each zone? Which animals were zoned? What kinds of adaptations must these animals have in order to live where they do? Did anyone notice that the spiny urchins living in the wave battered area are all embedded in pukas? Why might they do this? Do you know how the different animals hang on? (You could spend some time with this one. Students could collect a couple of each kind of animal and try and figure out how it hangs on. Sea urchins use "tube feet" which have small suction cups. Mollusks have a single muscular foot. Sea anemones have an adhesive area. Mussels have strong sticky threads.)

TOPIC 4: CEMENT: ITS ORIGIN AND MANUFACTURE

This section includes a brief summary of how the coral rock is made into cement, and information on how to tour the Kaiser Cement Plant in Lualualei Valley.

Cement

The fossil reefs of the Ewa Plain and Lualualei Valley are quarried for use in the making of cement. There is a quarry site just mauka of the barge harbor (it's on your right as you turn off Malakole Road to get to the field trip site) and a cement manufacturing plant in Lualualei Valley.

Cement is made from a mixture of calcium carbonate ($CaCO_3$), silica, iron and aluminum. The cement plant uses fossil reef rock for the calcium carbonate, Australian sand for silica, and basalt from nearby basalt quarry sites for iron and aluminum.

The coral is crushed and mixed with the other materials and water until it is soupy. It's then put into a kiln and heated to 2600 degrees F.

This takes 2½ hours, and heats the material just to the melting point. This chemically combines the materials, and when it comes out it's dark, hard rock, called "Klinker". The Klinker is ground up, and that's cement.

Cement is bought by businesses like HC&D and Pacific Concrete and Rock Co. (PCR) that make and sell concrete. They mix cement with sand and rock to make concrete for construction products. Anyone can buy cement at a hardware store and make concrete.

Kaiser Cement Plant Tour

The Kaiser Cement Plant in Lualualei Valley is willing to tour a very limited number of school groups through their facilities. Interested teachers should write to Mr. J. Gifford, Plant Manager, Kaiser Cement and Gypsum Co., P.O. Box 2072, Nanakuli, Hawaii 96792. He requests that teachers write at least two weeks ahead of time, let him know the date and time they would like, and the number and ages of the students (he requests not more than 35 students). It is necessary that the students wear shoes and be accompanied by one adult for each 10 students. They can only handle one or two tours a month.

ACTIVITY VII - In-Class

While on the field trip mention that the fossil reef is used in the making of cement. Back at class ask the students if they know how it is used to make cement. If no one knows, have them research it rather than telling them. If you're both brave and creative you might think of a reason to make concrete in class*. Does a cement plant seem like a good industry for Hawaii? Why or why not?

*Molds can be made of a mixture of 3 parts sand and 1 part cement.

IDENTIFICATION GUIDE FOR TOPIC 3 (ZONATION) ACTIVITIES:

Sea urchins

1. Echinometra mathaei--spiny, light colored sea urchin (ina); 5-8 cm (2-3 in.) across. Echinometra oblongata--spiny, black urchin; 5-8 cm (2-3 in.).

2. Colobocentrotus atratus--flattened, purple sea urchins (ha 'uke 'uke); 5-8 cm (2-3 in.) across.

Mollusks (snail family)

3. Acanthochiton viridis--chitons; 2.5-5 cm (1-2 in.) long.

4. Moula granulata--knobby black shells; 1-2 cm (1/2-3/4 in.) across.

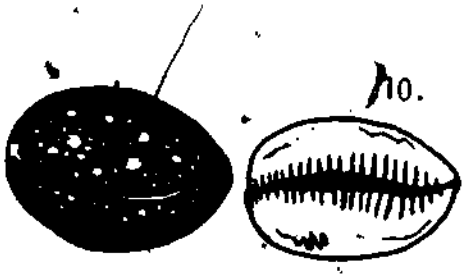
5. Drupa ricina--white shells with black bumps; 1-2 (1/2-3/4 in.) across.

6. Littorina sp.--periwinkles have pointed shells and are usually gray; 1 cm (less than ½ in.).

7. Nerita picea--nerites (pipipis) are round and black; 1 cm (less than ½ in.).

8. Unclassified--tiny dark shells live in large aggregations; 0.3 cm (1/8 in.).

9. Various species of sea anemones may be open, with tentacles out, or closed and covered with sand. They feel soft and spongy and contract when you touch them.



10. Cypraea caputserpentis--snake's head cowry; brown with white spots on top; 2.5 cm (1 in.).

11. Various species of hermit crabs live in discarded snail shells:

(See Field Keys to Common Hawaiian Marine Animals and Plants pp. D1-6.1.

12. Siphonria normalis--false opihis are whitish colored; about 1 cm (½ in.) across.

13. Brachidontes crebristriatus--mussels are black and grow together in a mass, or bed. They attach firmly to the substratum. Each mussel has 2 shells (like a clam). Mussels are about 1 cm (less than ½ in.) in size.

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FIELD TRIP III - HANAUMA BAY

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Instructional Goals

When faced with decisions concerning the use of terrestrial and extraterrestrial resources, students will select practices developed in recognition of present and future environmental and human needs.

Instructional Objectives

Collect information about the change of wildlife distribution in this community during the past 10 to 20 years and develop a public presentation on the topic.	LA, Sc, HS, Student Act, LS
Write a theme or prepare a speech about wildlife habitat management.	LA, Sc
Discuss the need for preserving natural areas and related legislative needs.	Sc, SS
Debate the resolution: "People do not need the great blue heron, timber wolf, killer or humpback whale, Hawaiian goose or other wildlife."	LA, SS, Sc, V
Discuss the use of hunting or fishing seasons or periodic closing of certain hunting or fishing areas to manage wildlife.	SS, Sc
Investigate various commercial fishing techniques and discuss their economic and environmental impacts.	Sc, SS, C
Discuss the physical features of the coastal zone areas of Hawaii.	SS, Sc, HS

Performance Expectations

Describes instruments or methods that can be used to gain information about environments or change an environment for a desired result.

Conducts simple investigations to gain first-hand information on environmental matters.

Integrates information gained from resources with information gained through direct experiences to develop understanding of environmental matters.

Describes the environmental factors which must be considered to conduct various recreational activities.

Explains the effects of environmental changes on recreational opportunities.

Explains the potential effects of changes in recreational activity on the environment.

Cites examples of negative and positive ways human beings can change the environment.

Identifies specific contributions one can make to help human beings live in harmony with the environment.

Compares the aesthetic value of maintaining natural environments with the need for housing, improved transportation facilities, and increased employment opportunities.

Essential Competencies

Reach reasoned solutions to commonly encountered problems.

Distinguish fact from opinion in TV and radio news broadcasts, advertising, newspaper and magazine articles, and public speeches.

Use resources for independing learning.

Demonstrate knowledge of citizen rights and responsibilities.

TOPICS DISCUSSED:

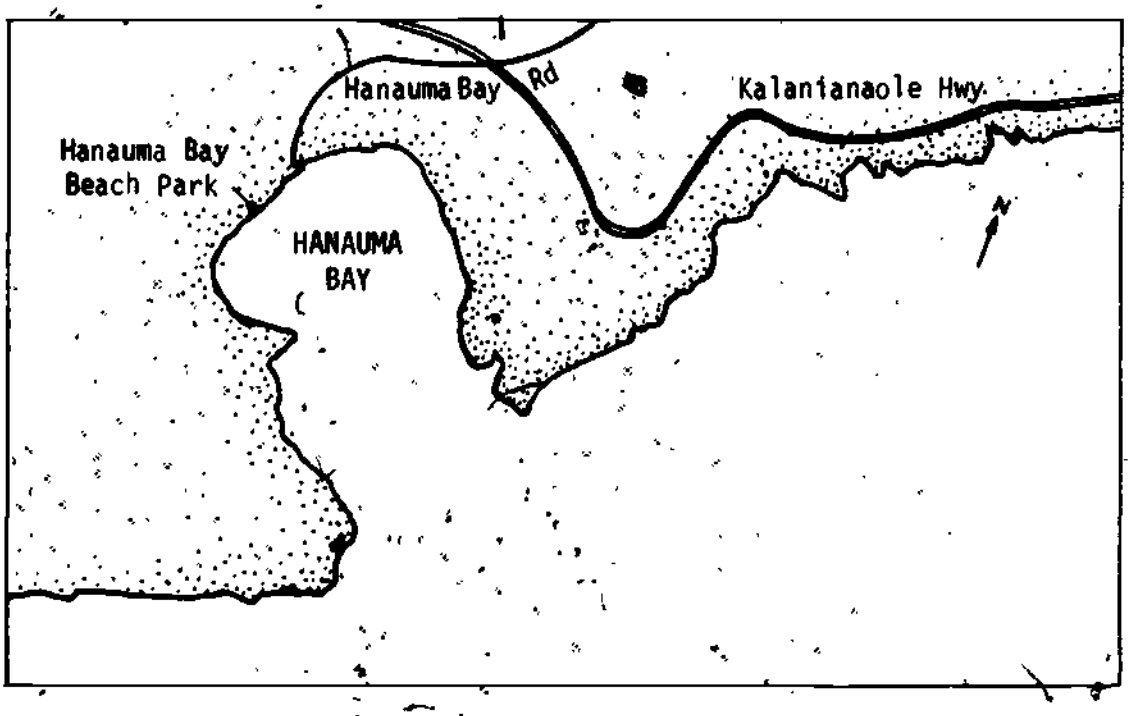
1. MARINE CONSERVATION
2. GEOLOGY OF HANAUMA BAY

FIELD TRIP SITE:

Hanauma Bay is located on the southeastern tip of Oahu. It can be reached by Kalanianaole Highway from either the windward or leeward sides of the island. Signs indicate the turnoff to the bay.

This bay is a marine conservation district and taking any marine life, shells or sand or possession of any nets, spears or other fishing gear is prohibited.

Facilities include restrooms, showers, a snack bar, and picnic tables.



INTRODUCTION:

Hanauma Bay is a well-known Marine Conservation District. It offers a protected environment where residents and tourists alike can enjoy the islands' reef life. It is also of geologic interest; a short walk allows observation of many interesting and easily recognizable geological formations.

The "marine conservation" aspects of Hanauma Bay will be treated as in-class activities; while examination of the geology of the areas will be the focus of the on-site activities.

PHYSICAL DESCRIPTION:

This small, deep bay is one of a series of prominent landmarks which were formed by geologically recent volcanic eruptions. It is a tuff cone, the walls of which are embedded with pieces of limestone and basalt. A sandy beach lies at the head of the bay, while both sides are rimmed by a wave-cut bench. A fringing reef protects the inner bay from the force of the waves, and creates a calm, shallow-water environment.

BIOLOGICAL DESCRIPTION:

Hanauma Bay provides diverse habitats for a wide variety of reef life. Habitats available include rocky shorelines, tidepools, sand patches, live coral, and shallow and deep reefs with their associated varied topography.

Historically, Hanauma Bay was a popular fishing area. The increased fishing pressure which accompanied the growing Oahu

population seriously depleted the resident fish population. Many of the fish found in the bay were herbivores, or algae eaters. Their removal had the secondary effect of allowing increased algal growth. Since being designated a Marine Conservation District in 1967, fish populations have increased markedly and accumulations of seaweeds have been grazed down.

TOPIC 1: MARINE CONSERVATION

A "Marine Conservation District" is an area where marine life is protected, and Hanauma Bay was the first such area established by the State of Hawaii. Hanauma Bay is governed by Regulation 32 in our state statutes. It is stated in this statute that at Hanauma Bay it is

> "unlawful for any person to hook, spear, seine, capture, injure, kill, destroy, alter, deface, possess or remove any fish, crustacea, mollusk, sea shell, coral or any other plant or animal life, or any rocks, sand or any geological features, from the Conservation District. Possession by any person of fishing gear, including, but not limited to hook and line, rods, reels, seines, and spears, crowbar and noxious chemicals, within the Conservation District shall be deemed to be prima facie evidence of violation of this regulation."

Further, this regulation states that it is illegal to pollute or contaminate the waters within the Conservation District; and that "this includes depositing bottles, cans, paper garbage, food and other refuse, washing clothing and other items, bathing animals, and cleaning fish." (Hawaii Laws and Statutes, 1976). Violation of this statute is a petty misdemeanor punishable by a fine of up to $100.00 or a jail term of not more than 30 days, or both. This law is enforced by the Department of Land and Natural Resources, Division of Fish and Game.

A major hindrance to enforcement is the lack of sufficient

personnel. Fish and Game wardens must patrol the entire state, not only protecting the conservation areas, but enforcing all fishing regulations. These regulations include such things as size limits, bag limits and closed seasons. Illegal fishing methods are also a concern of the wardens. (See Activity I for a slide-tape show available on our present day laws as they relate to marine life and enforcement.)

Marine Conservation Districts are established for a variety of reasons. They preserve and conserve natural resources for public appreciation and aesthetic enjoyment. They assure the survival of marine ecosystems by preventing the shell collectors, coral collectors, and fisherman from over-fishing the reef. "Marine parks help conserve the resources in a nonconsumptive manner. In addition, the protected species within park sanctuaries provide larvae and migrants for adjacent areas open to fishing and shelling." (Hawaii and the Sea, 1974)

The power to establish a Conservation District lies with the Dept. of Land and Natural Resources under Chapter 1980 of the Hawaii Revised Statutes. Regulations regarding a proposed conservation area are drawn up, public hearings are held, and finally, the Governor's approval is needed. There are no objective written policies for the selection criteria; however, abundance of life, clear water and compatible use with the adjacent lands are essential factors in site selection. The need for additional Conservation Districts and criteria for selection was studied and published by William J. Kimmerer and Woodrow W. Durbin Jr. in the pamphlet entitled The Potential for Additional Marine Conservation Districts on Oahu and Hawaii. This publication is available through Sea Grant and at most of our local libraries. Kimmerer and Durbin (1975) set up a selec-

tion criteria system composed of 3 categories: geography, physical oceanography, and marine life. These areas were broken down as follows:

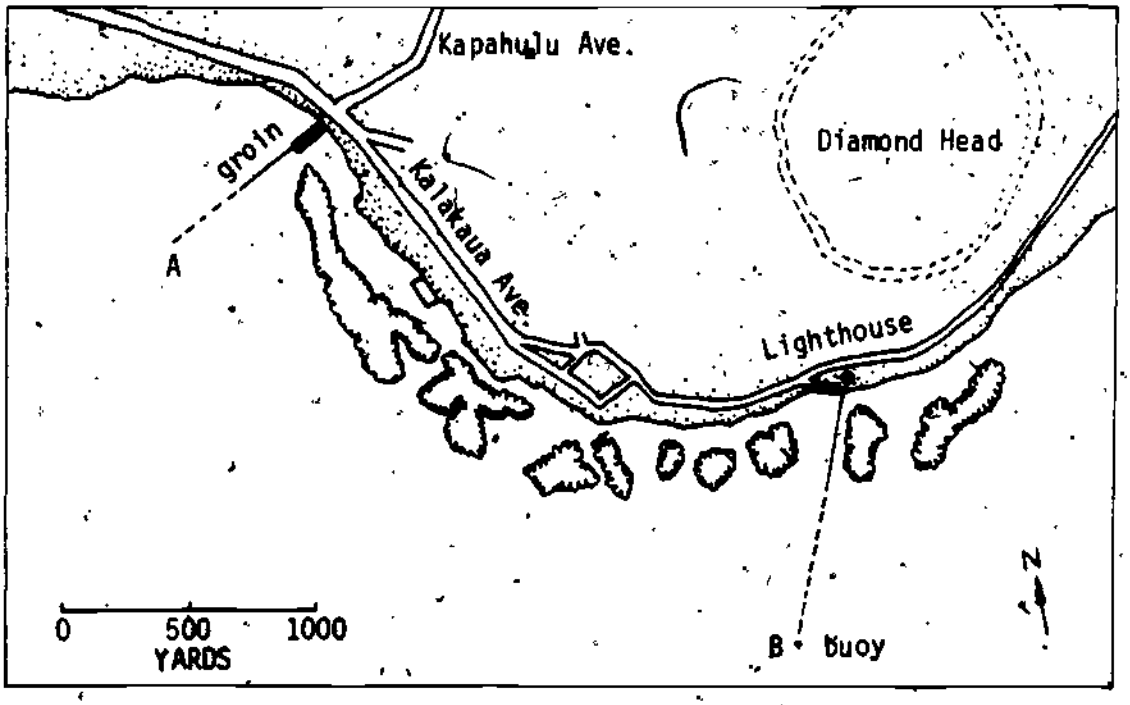
1. Geography
   - •Ease of definition of area boundaries for recognition and enforcement
   - •Compatibility of the present and planned use of the adjacent land with a marine park
   - •Access to the shoreline from existing roads
   - •Access to snorkeling and diving areas from the shore
2. Physical Oceanography
   - •Exposure to seasonal surf
   - •Exposure to trade winds and waves
   - •Current strength
   - •Underwater visibility
   - •Water temperature
3. Marine Life
   - •Abundance and diversity of fish
   - •Coral cover and diversity
   - •Abundance and diversity of large motile invertebrates

From their studies they recommended Kahe as a first choice for a new Marine Conservation District if a new beach park is established there, and secondly, Pupukea. Studies conducted by the State Department of Planning and Economic Development and published in Hawaii and the Sea (1974) made similar recommendations. Part of Waikiki was added as a third choice.

Permanently closing an area to fishing is not the only way to pro-

tect it, and several systems of conservation have been suggested. Periodically closing an area and backing the closing with strict reinforcement until the area replenishes itself is a possible solution. Rotating conservation areas on a 3 to 5 year basis or limiting the life of the district to 10 to 15 years has also been suggested.

On July 1, 1978 part of the Waikiki reef was closed to fishing for a period of two years. This area was not called a "Conservation District", but rather a "Shoreline Fisheries Management Area". It was an experimental approach to resource management and part of the state's "Kapuka Plan" (Kapuka = to restore life). The area affected ran from the Diamond Head light house to Kapahulu Avenue and extended from the high-water mark seaward to 500 yard mark. (See map) All fishing was prohibited until 1980, when only hook and line fishing was allowed. In 1981 all legal fishing methods was permitted. Limu picking was not affected by the fishing ban, but coral harvesting is prohibited permanently.



Closing an area or establishing it as a conservation district does not please everyone. Environmentalists and those who fish are often in direct conflict. Naturally, anything that affects a fisher's catch is threatening to his/her livelihood. However, only through wise conservation measures is it possible to save some of the harvest for future generations.

ACTIVITY I - In-Class

Objective: To understand the past and present-day methods of conserving marine life in Hawaii.

Procedure: The Sea Grant Marine Advisory Program has two slide-tape shows available to teachers. The first one, "Ancient Hawai'i in Harmony with the Sea", discusses the traditions of the past. The second, "I'a of Hawaii, The Present Day Kapu", discusses present-day fishing regulations.

To arrange for these slide shows call Sea Grant Marine Advisory Program, 948-7031, at least two weeks before you will need them. These slide shows contain a great deal of information and should give students an appreciation for the concept of conservation.

The Sea Grant Marine Advisory Program has prepared 4 small brochures to accompany these slide shows which are available in the pamphlet files of the State Libraries or from the Sea Grant office. These brochures include:

1. "Ancient Hawai'i in Harmony with the Sea", which discusses the ancient traditions concerning marine conservation;
2. "Ula and Papa'i - Lobster and Crab";
3. "He'e and 'Olepe - Octopus and Shellfish", which discuss the fishing regulations pertaining to these animals; and

4. "Illegal Fishing Techniques in Hawai'i", which discusses the illegal methods used and their consequences.

ACTIVITY II - In-Class

Objective: To understand why different parts of the community disagree on the establishment of conservation areas.

Procedure: This activity involves debating and role playing. The class is going to debate the pros and cons of closing an area. The debate could involve an area like Hanauma Bay or Waikiki, or the class can choose a site such as Kahe or Pupukea which has been recommended as a possible conservation area. Some classes might choose to pick an entirely different site and debate the issues concerning it. Let the students assume roles. One might want to speak up as a person supporting a family on the income he/she receives from fishing. Others might represent someone that merely supplements their monthly food budget with fresh fish. Have your resident zoologist speak out. Let the class really talk out the problems and promises of a Marine Conservation District.

Another debate could center on illegal fishing techniques used in Hawaii. Why are they used? Should stricter laws be passed? How can enforcement be improved?

ACTIVITY III - In-Class

Objective: To discuss the usefulness of marine conservation areas.

Procedure: Ask the class the following questions to stimulate discussion:

1. How many students have been snorkeling at Hanauma Bay?
2. How many have been snorkeling at other places on Oahu?

3. Did you notice any difference in the number of fish between Hanauma Bay and other places?
4. How would you feel if tomorrow Hanauma Bay was no longer a conservation area?
5. What would happen there?
6. Do you think this would be good or bad? Explain.
7. Of what use are marine conservation areas?

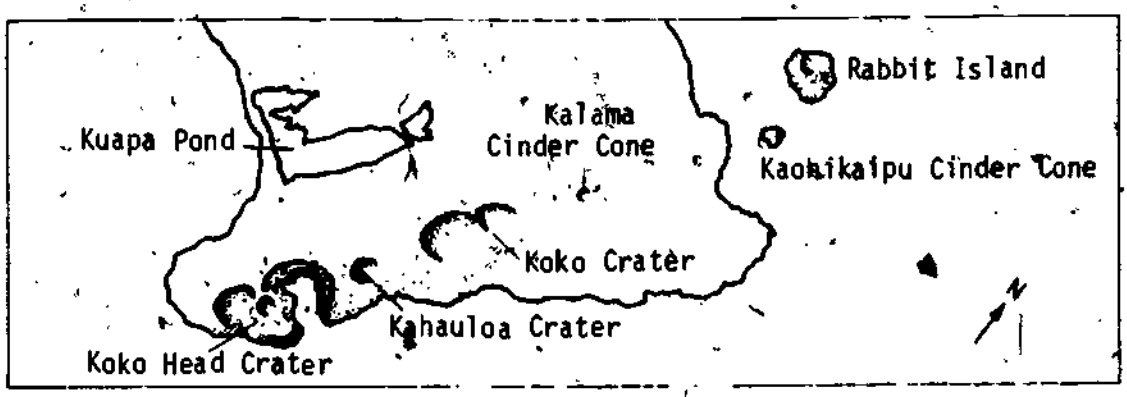
TOPIC 2: GEOLOGY OF HANAUMA BAY

This section includes background on the geology of the bay, and a running commentary to accompany a nature walk there.

HISTORY

Hanauma Bay was formed approximately 40,000 years ago. After the eruptions which formed the Ko'olaus had ceased, there was a

> "period of volcanic quiet which probably lasted at least two million years. Then, on the southeastern end of the Ko'olau Range, volcanic activity resumed. More than 30 separate eruptions formed cinder, spatter and ash cones and poured lava flows over the deeply eroded topography and out onto the fringing reef. These constitute the Hawaii Volcanic Series, and have given us some of our best-known landmarks, many of them in or near the city of Honolulu: Diamond Head, Koko Head, Hanauma Bay, Punchbowl, Tantalus, and Salt Lake." (Macdonald and Abbott, 1970)

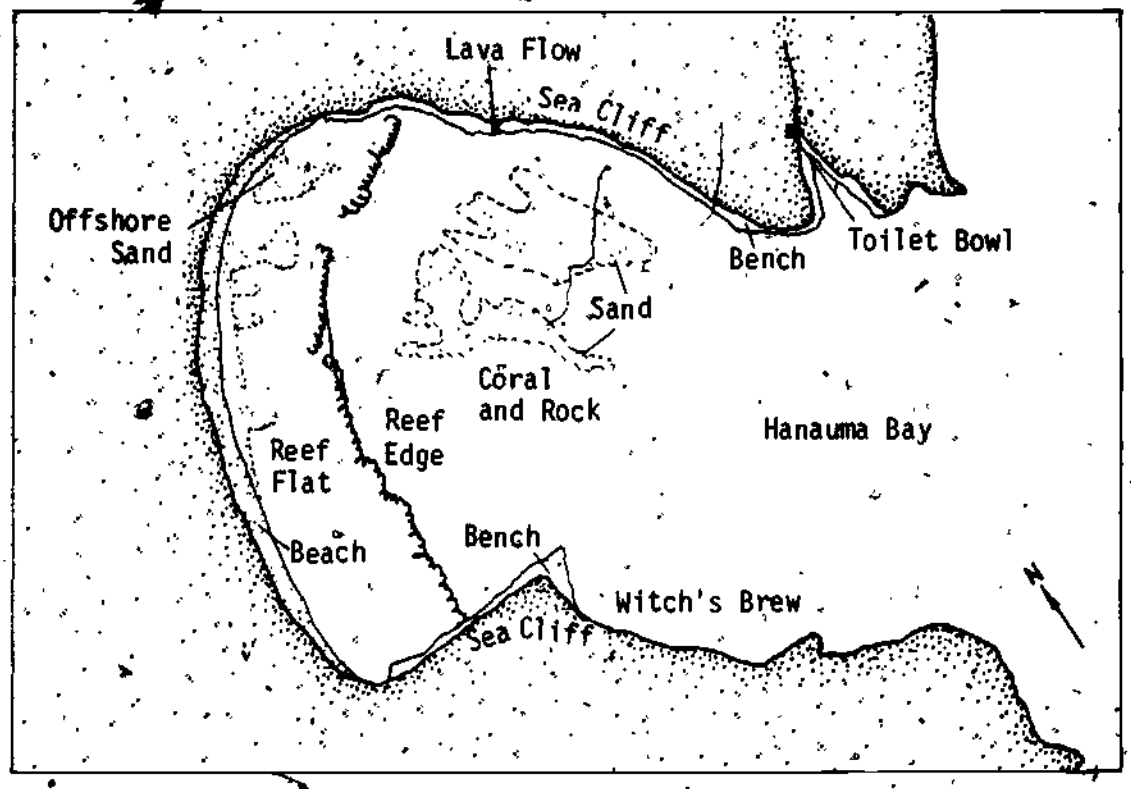


Hanauma Bay is a "tuff" cone. Volcanic eruptions that come in contact with water cause violent explosions. These explosions produce a fine ash, rather than a solid lava flow. The ash settles on the land and quickly becomes cemented due to the chemical reaction of the material. (Stearns, 1966. pp. 86-87, Macdonald and Abbott, 1970, pp. 18-22) The hardened ash is called "tuff". Diamond Head, Koko Head, Koko Crater and Manana (Rabbit) Island are also tuff cones.

ACTIVITY IV - On-Site

Objective: To learn some geology of Hawaii, using Hanauma Bay as a site for a geological nature walk.

Procedure: Information on various geological features and photos of some of these are provided. Rather than simply telling the students the information, you might use the "inquiry" approach, forming questions from the material provided.



Begin the nature walk at the top of the bay, along the lava rock wall.

(Photo 1) Hanauma Bay is a "compound crater" and was formed by at least six tuff cones. Part of one of these cones can be seen on the right-hand side of the bay just above the end of the sandy beach. It appears as a large funnel or "V" shaped area in the crater wall. The sloping dirt shows the origination of the cone.

Photo 1

(Photo 2) The reef at Hanauma Bay is a "fringing reef" - one that grows along the margin of the land. The "back reef" area near the beach is composed largely of sand or coral rubble. Notice that the top of the reef or "reef flat" is not solid and continuous, but honey-combed with openings of all sizes. It is this diversity of topography that allows a great many animals to live on a reef.

Photo 2

The "fore reef", or reef front, absorbs the force of the waves, protecting the beach from erosion. Notice that the front of the reef is broken by many small surge channels which help dissipate wave energy. (How do they do this?)

The volcanic activity that formed this bay originated beneath existing layers of basalt (lava) and limestone reef. The eruptions caused these layers to be blasted apart, and the pieces fell back to earth to become imbedded in the tuff. As you walk down the road to the bay notice the wall of tuff and the many pieces of small white and black rocks.

(Photo 3) Once at the beach, walk along the left-hand side of the bay until the sandy beach ends and a hard platform begins. This is a "wave-cut bench", which was cut from the tuff by the action of the waves. Notice that the walls of tuff behind the bench have been undercut by wave action. The beneh appears black rather than tan, because of a thin layer of bluegreen algae which grows over the wave-wetted surface.

Photo 3.

As you walk along the bench on the way to the "lava arch" look for greenish colored sand to your left. There are very few beaches composed of green sand in the Hawaiian Islands, and Hanauma Bay is one of the best examples. "The sand consists of green crystals of olivine, separated out of the volcanic rocks by erosion. At Hanauma Bay the rock supplying the olivine is tuff..." (Macdonald and Abbott 1970). Olivine is a young mineral, found in areas of recent volcanic activity.

Photo 4

(Photo 4) One of the most interesting geological features of the bay is the small lava flow on the eastern side of the crater wall, which has formed a natural arch. The sand in this area is composed of black and white fragments. The black sand is formed by the erosion of the lava, while the white sand has been eroded from pieces of coral and shells. The basalt is easily distinguished from the tuff, as it is black and stony. Just before you pass through the arch look to your left in order to see "pahoehoe" lava. Pahoehoe forms a smooth or ropy surface. The other major form of lava is a'a, which has a rough, rubbly surface (Macdonald and Abbott, 1970, pg. 22).

(Photos 5 & 6) After passing through the arch, you will come to a rock fall. Look at the cliff above the rock fall and notice the exposed root systems. The roots penetrate small cracks in the earth near the cliff, and as they grow and expand large chunks of tuff are separated from the wall, falling to the bench below. They will eventually be eroded away by wave action.

Photo 6

Photo 5

Once past the rock fall, look across the bay to the funnel shaped cone described earlier. Two other cones can be seen from this vantage point. One is to the right of the previously observed cone, and one is to the left, above the area called "Witch's Brew". (Photo 7) (Look for the dirt sloping inwards from both sides.)

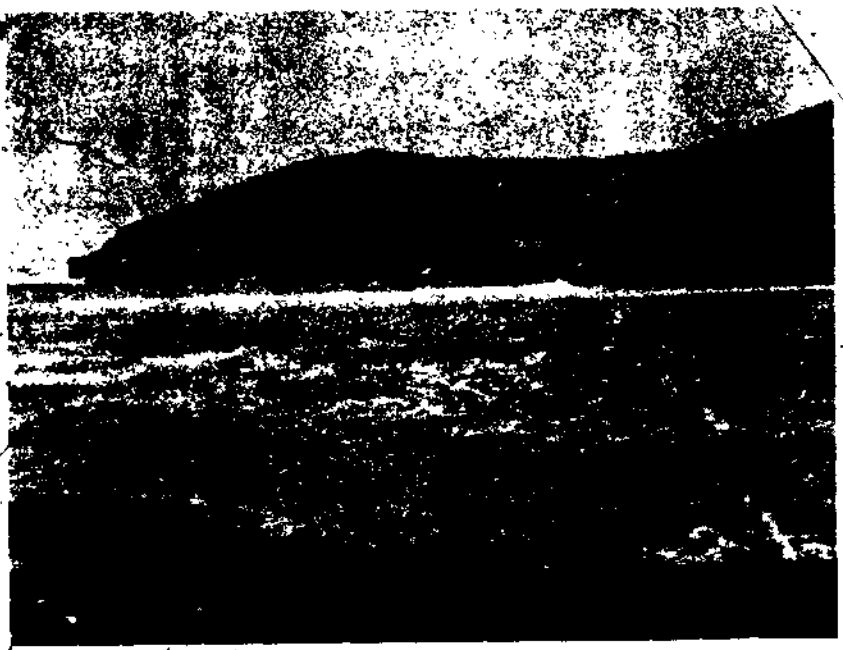


Photo 7

(Photos 8 & 9) Turn your attention now to the wave cut bench. From where you are standing notice that the inshore end of the bench (near the sandy beach) is very close to sea water level. Look out to the point and notice that the bench there is significantly higher. Macdonald (1970, p. 356) explains this phenomenon:

Photo 8

"The heavy surf along the more exposed parts of the coast keeps the rock face of the cliff saturated (with seawater) to a higher level than do small waves in more protected areas. The water-saturated tuff is more resistant to erosion than the unsaturated tuff above it, (emphasis ours) and the latter is more rapidly cut away, leaving the bench."

Your nature walk can end here, if necessary. If you have the time and the surf is small, a walk around the point will bring you to a local point of interest called "the toilet bowl". Near the point

Photo 9

you can see wind and water sculpturing in the tuff high above sea level, large chunks of old reef embedded in the crater wall at the point, and expanses of olivine sand near "the toilet bowl".

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FIELD TRIP IV - KEWALO BASIN

FIELD TRIP IV - KEWALO BASIN

Instructional Goal

When faced with decision concerning the use of terrestrial and extraterrestrial resources, students will select practices developed in recognition of present and future environmental and human needs.

Instructional Objectives

Discuss the physical feature of the coastal zone areas of Hawaii.	SS, Sc, HS
Discuss the change in flora and fauna from the seaward limit of the coastal zone to the landward limit.	Sc
Explain why algae and coral are renewable resources and discuss the constraints on this renewability.	Sc, SS
Identify and explain important fuctions of algae and corals.	Sc, N

Performance Expectations

Use a variety of resources to gain information on environmental matters.

Conducts simple investigations to gain first-hand information on environmental matters.

Integrates information gained from resources with information gained through direct experiences to develop understanding of environmental matters.

Essential Competencies

Reach reasoned solutions to commonly encountered problems.

Use resources for independent learning.

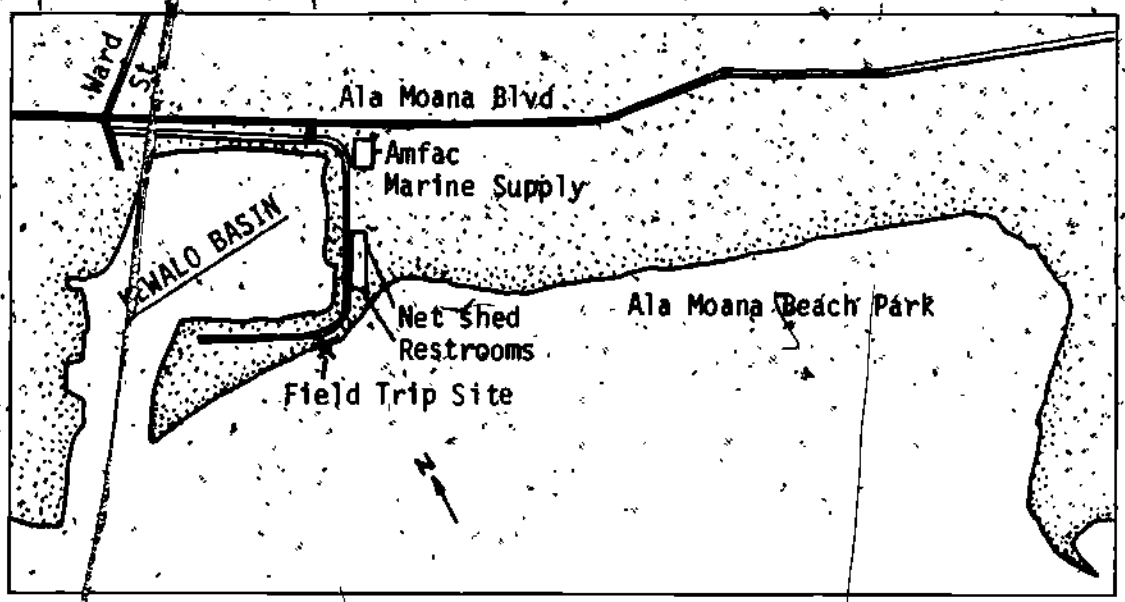
TOPICS DISCUSSED:

1. REEF FLAT STRUCTURE AND ECOLOGY
2. MARINE INVERTEBRATES INHABITING REEF FLATS

FIELD TRIP SITE

Kewalo Basin is a commercial boat harbor in Honolulu, across from the Ward Warehouse on Ala Moana Blvd. The field trip site is the reef flat on the ocean side of the basin.

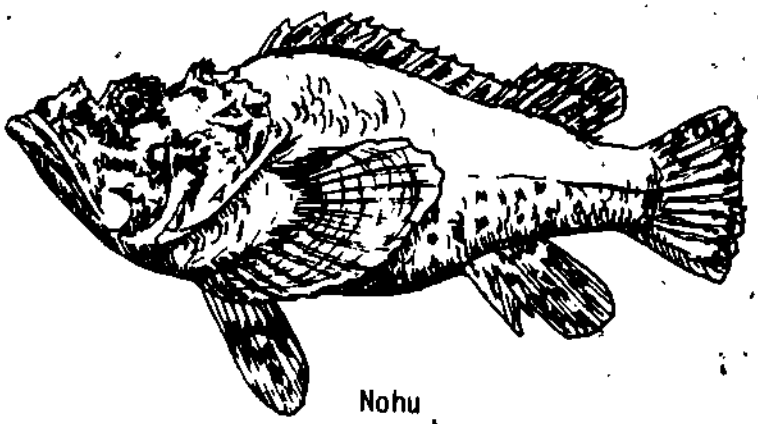
Enter Kewalo Basin from Ward Street intersection if you are driving in an Ewa direction, or at Amfac Marine Supply (formerly McWayne's) if driving in a Diamond Head direction. Take the road in front of Amfac Marine that heads towards the ocean. The site is on the ocean, just past the bend in the road (see map). Park in the public parking area rather than in the restricted parking area (observe posted parking regulations).



There are restrooms in the large, roof-covered net repairing area. It is important that you visit this site on a zero or minus low tide. Plan to arrive about an hour before maximum low tide (see newspaper for tide information).

SAFETY

Students must wear tennis shoes or reef tabis. Slippers are not acceptable. Scorpion fish (nohu) are common in this area, and might be stepped on. When handling unfamiliar animals, use chopsticks or gloves.



Nohu

When turning over rocks, use gloves. There are hazardous animals such as "wana", the long-spined sea urchin, fire or bristleworms (large pink worms with many white bristles along each side), and an occasional small eel. Scorpion fish are usually 3-8" long and are camouflaged to blend in with the sandy bottom. They sit quietly, darting away quickly when disturbed. They are not aggressive and would only cause harm when picked up or stepped on, as a venom carrying spine could penetrate the skin. They are not deadly, but very painful.

INTRODUCTION

A fringing reef is a reef that is found along a shoreline, and most of the reefs in the major Hawaiian Islands are this type. Extensive fringing reefs front the shore between Hawaii Kai and Ala Moana Beach Park. A "reef flat" is the top surface of the reef. Reef flats are accessible, generally safe, and harbor many interesting forms of marine life.

PHYSICAL DESCRIPTION

The shallow reef area fronting the Kewalo Basin breakwater is the ewa end of the extensive Ala Moana reef flat. This area offers calm water and mixture of hard and soft bottoms. The "backreef" portion directly in front of the breakwater is covered with rocks and rubble. This area is exposed at low tide. Seaward of this are larger, algae-covered rocks on a sand bottom. This area merges into the solid reef platform. The structure of the solid reef is interrupted by holes and sand patches.

BIOLOGICAL DESCRIPTION

Reef flats provide a variety of calm water habitats for plants and animals. While there is little live coral to provide hiding places for animals, there are rocks, crevices, holes, sand and rubble.

In the rocky area fronting the breakwater small crustaceans and sea anemones can be found under the rocks. In the large rock and sand area a variety of animals are found under and in the rocks, in the algae and in the sand. The more seaward reef platform hosts small fishes in the

large holes, while invertebrates are found in crevices and in the sand.

TOPIC 1: REEF FLAT STRUCTURE AND ECOLOGY

This section includes a reprinting of an article that occurred in the May 1978 issue of the Hawaii Coastal Zone News. Much of the information given about reef flats in this article can be seen first-hand on a field trip to any reef flat area, and field trip activities involve doing just that. Paragraphs are numbered for later reference.

Reef flats (from Hawai'i Coastal Zone News, May 1978)

P1 Hawaiian nearshore reef flats hug much of the shore line of all the major islands, except for the island of Hawai'i, due to its geological youth. The wide shallow platforms extend seaward as much as one half mile, and are never very far below sea level. The depth of water over the reef flats is between one and 12 feet, although the low point in the lunar tide cycle may leave some sections exposed.

P2 Nearshore reef flats include both apron and fringing reef types. The first represents an earlier stage in reef growth leading to the second. Apron reefs are smaller and discontinuous, projecting out from the shore as semicircular structures. In time, these may fuse to form broad continuous-fringing reefs that parallel the coastline for long distances.

P3 Reef flats have a variety of surface features. The shoreward portions are usually sand bottoms, often mixed with stones and strewn with large fragments of reef rock. The seaward portions are solid reef, cut by numerous channels (which break up the force of the waves.)

The living reef

P4 Bottom-dwelling organisms are the architects of the reef mass. When alive, lime-secreting (coralline) algae and stony coral polyps continuously remove minerals from seawater to form skeletons of self-made limestone. When they die, their skeletons contribute the bulk of the rigid "frame" of the reef. This frame creates an anchorage on, around, and within which other organisms can grow, and upon dying, add to the structure or skeletal debris. The hard skeletons left by mollusks and sea urchins and the powdered remains of one-celled animals (eg. Foraminifera) and sand-producing algae (such as Halimeda) gradually fill the cavities in the porous limestone framework with sediment. Coralline algae provide most of the "cement" which solidifies the other components into a consolidated reef

mass. The lime-secreting algae, particularly Porolithon, strongly dominate the reef edge, or crest, which meets ocean waves head-on.

P5 Reef-building organisms normally cannot tolerate the climactic extremes occurring near the sea surface, and as a consequence, few reef flats grow to sea level and emerge at low tide in Hawai'i. Thus, extension of the reef flat occurs primarily in a horizontal direction, away from the shore, once the upward limit of growth is attained. Reef growth in any particular location depends partially upon the severity of inhabiting factors. For example, flats on the windward sides of islands subjected to heavy wave action, fresh-water runoff and natural sedimentation are unlikely to grow as vigorously because reef-building organisms are under great stress. In leeward locations where conditions are more favorable, reef flats may grow upward to very shallow water depths.

Dependable tenants

P6 Because reef flats offer a variety of habitats, the distribution of life is patchy. Where there are solid or rubble surfaces, there is a rich cover of seaweeds, particularly just below the waterline. Inshore, where water circulation is sluggish, the fleshy alga Acanthophora (which was probably introduced to Hawai'i on the bottom of a boat) may be found. Where water movement is more vigorous, coralline algae (particularly Porolithon) and limu kala (Sargassum) are more abundant. Populations of small crustaceans use the elegant camouflage of bottom-dwelling algae for shelter.

P7 Invertebrates, such as mollusks, small crabs and shrimps, and segmented worms are also present on reef flats but the majority are concealed life forms that have retreated from the surface. Their ingenious exploitations of space may not be revealed unless the bottom is sifted or cracked open. Dead reef is a penetrable surface housing animals such as sponges and worms that bore or excavate tunnels by dissolving or mechanically grinding the rock. Secondary species become tenants in burrows abandoned by the pioneers.

P8 Where there are sand patches, mollusks such as the flea cone (Conus pulicarius) and auger shells (Terebra), lie buried under the surface. High water temperatures, low salinity, mud that pours out from streams during rainy seasons, and drifting sand also check the growth of stony corals close to shore, so they are not usually important components of reef flats, except at the seaward edges.

P9 Both biologically constructive forces (lime-secreting organisms) and physically destructive forces (wave action and scour, breakdown by living things) are constantly acting on a reef with different degrees of success. In one spot, the balance of forces may be extending the reef sideways or upwards, in another - breaking it down, and elsewhere maintaining it more or less in uneasy equilibrium.

P10 Storm waves and swells break and wrench pieces of rock from the seaward side of the reef. In places this action undermines the edge of the reef and is followed by collapse of large sections.

The perforating, boring tunneling and dissolving activities of algae, sponges, mollusks, worms, sea urchins and some fish also grind the solid reef into sediments of all sizes. This pulverized material fills in spaces in the reef rock, slides down the steep seaward wall of the reef, or is carried over the reef and is deposited on the shoreward side. In this way, the region between the reef and shore slowly fills with sand while it contributes to the destruction of the solid reef mass. On reef flats near streams, silt from the land may build up faster than it can be removed by wave action, and mud flats cover the reef flats, such as at Kane'ohe Bay.

ACTIVITY I - Pre-field trip

Objective: To learn to recognize coralline or "stony" algae.

Materials: Slide set of coralline algae, available through your school's district office.

Procedure: The importance of coralline algae on the reef is explained in paragraph 4. It not only cements the reef together, but helps build it too. This slide series shows the different forms of coralline algae, and should help students recognize them on the field trip.

ACTIVITY II - On-Site

Objective: To show that reef flats have a variety of surface features and that they change in makeup from shore to sea. Refer to Paragraph 3, page D6.

Materials:

1. Two or three hula hoops, or metal frames 2/3 to 1 meter on a side.
2. A ball of string 30 m long, marked at 3 m intervals with colorful ties.
3. Clipboard, paper and pencil for each student group of three or four.
4. At least one lookbox for each student group of three or four.

Procedure: This activity involves running a transect line out onto the reef from the shore and describing the bottom at 3 m intervals, using the hula hoop or metal frame to define the observation area. Each student group would draw to scale the topography within one observation area and lable the different kinds of substrate, such as sand, rocks, holes, rubble, etc. Each tie on the line should be numbered 1-10, beginning from shore, and each group should be assigned a number. They then need only to count the ties as they move from shore across the reef to find their area.

In-Class Follow Up

Place the drawings in order along the blackboard. Students should look at the drawings in sequence and answer the following questions:

1. Do reef flats have a variety of surface features? Name some.
2. Can you see any general change in the bottom topography as you move from shore to sea? If so, what? Compare your findings with generalizations made in paragraph 3 of "reef flats".

ACTIVITY III - On-Site

Objective: To identify coralline algae in the field.

Procedure: Have students turn over a few rocks on the reef flat and look for pink or purple on the undersurface. Look also for pink or purple color on shells or coral rubble. The pink and purple is a thin crust of a kind of coralline algae. Among the coral rubble look for small heads or chunks of coralline algae. They often look like small coral heads (a few cm across) but corals always have small holes over the surface, and this hard algae is smooth and lumpy.

Once students find some, restate its role on the reef. (Campbell Harbor field trip also has information on these reef building algae.)

ACTIVITY IV - On-Site

Objective: To see the structure made by stony coral polyps. Refer to paragraph 4, page D6.

Materials: 1. Something to chip off a piece of dead coral rock. A small hatchet or hammer and chisel would do.

Procedure: There is little live coral on the reef top, but lots of dead coral chunks. To see that this is true, find what you believe to be a coral rock. It will appear light in color rather than black. Chip at a corner of it. If it is indeed a coral rock, the area you are chipping at will appear white and be rather soft (soft for rock that is). Once a piece has been chipped away, the exposed surface will appear white and finely porous. This is the skeleton of a reef-building coral. The tiny holes which give the porous nature to the rock were once the cups that the polyps lived in. They grow new ones layer on layer.

Save this coral for the next activity.

ACTIVITY V - On-Site

Objective: To observe animals that have "retreated from the surface". Refer to paragraph 7, page D7.

Procedure: Using the cracked-open coral rock from the previous activity, look along the inner edge of the exposed surface for tiny worms and their holes. Look also for larger holes about ¼ inch in diameter. These holes are made by worms too. Look on the surface of the coral rock for holes

and crevices. Do you see animals in them? Try and break more of the coral surface to expose other animals. DO THIS WITH ONLY ONE OR TWO CORAL ROCKS. THESE ARE HOMES TO MANY ANIMALS. A dark green band of color along the inner edge of the surface indicates boring algae.

ACTIVITY VI - On-Site

Objective: To observe how the reef grows. Refer to paragraph 5, page D7.

Procedure: Notice if the reef breaks the water at low tide. Discuss the ideas presented in paragraph 5 about the reef only growing to a certain height because of "climatic extremes occurring near the sea surface." What climatic extremes might limit the upward growth of the reef? Would the reef grow better toward the sea or toward the shore? Why? How are reefs like this one important to islands?

TOPIC 2: MARINE INVERTEBRATES INHABITING REEF FLATS

This section includes descriptions of animals common on reef flats and simple activities students can do with them in order to learn more about their various natures. Included also is a script for a slide show on reef flat invertebrates. The slides are available from your district office.

ACTIVITY VII - Pre-Field Trip

Each district office has a series of marine life slides which you can borrow. Use these slides to show your class what the various animals look like that they are likely to see on the reef flat.

The slides are numbered, and the following slide script tells what

slide to use, what animal it shows, and where the animal lives. More information is provided in the book containing the slides which you may also want to use.

Slide #	Name of Animal	Habitat
4	Live coral	Lives on the tops of shallow reefs
9	Sea Anemone and live coral	Both found on tops of shallow reefs
10	Sea Anemone and coralline algae	Under rocks
17, 18, 20	Flatworms	Under Rocks
22	"Ina" sea urchin, and orange sponge	Under rocks and in pukas. Sea urchin not venomous
23	"Collector" or short-spined sea urchin	Lives out on reef, covers itself with debris, perhaps for camouflage
28	Featherduster worm	Lives in a tube. Tube usually under a rock or in a crevice
30	Bristle worm	Lives under rocks. Irritating to humans
41	Snakeshead cowry	Lives under rocks on reef flats (elsewhere in other habitats)
32	Money cowry with mantle out	Under rocks
49, 50	Cone shells	On reef flat. Handle with caution
95	Hermit crab	Various places on the reef flat. They use an old snail shell for a home
93	Hermit crab and sea anemones	Out on reef flat. Only this species of hermit crab puts anemones on its shell.
77	Decorator crab	These crabs put algae on their bodies for camouflage
75	Swimming crab	Under the sand

79	Black finger crab	Under rocks and in pukas in rocks
87	Mud shrimp	In burrows in the firm sand areas
164	White brittle star	Under rocks in sandy areas
162	Sea cucumber	Under rocks in shallow water
24	Wana	On reef rocks. Handle with caution

ACTIVITY VIII - On-Site

Objective: To observe reef flat animals.

Materials: Your class will need lookboxes (see appendix on how students can make their own), reef shoes (tennis shoes or tabis), gloves and chopsticks, buckets and flat pans for putting specimens in. For the brittle star experiments use a 9" x 13" cake pan. You might want to bring magnifying glasses or dissecting microscopes in order to see the animals more closely.

Please turn rocks right-side up after you look under them. The animals beneath the rock will die if exposed, and the algae on top of the rock will die without light. DO NOT take any animals back with you. This is a heavily used area and if your class removes marine life there may not be anything for the next class to see. Please kokua.

Re-read the "safety" section under "Kewalo Basin Field Trip Site", page D4.

Procedure: Most invertebrates do not live on the surface of the reef. Many live under rocks and you will need to turn over these rocks to find them. (Replace the rocks as you found them!) Look also in the pukas of the

rocks and in the sand. Some of the animals you will see are listed below. (See general appendix for identification information).

Colorful Filter Feeders

Soft, brightly colored or white colonies of sponges and colonies of various kinds of animals live on the undersurfaces or rocks. Sponges generally feel spongy and cloth-like; other colonies may feel crusty or slippery. Usually they are dotted with holes. These animals are filter feeders, which means they draw in water and plankton for food through some holes, and expel wastes through other holes. Look at these with a magnifying glass if possible.

Sea Anemones

Small, dark sea anemones cling to the undersurface of the rocks.

Kewalo basin has a dark species, about ½" in diameter, that attaches large sand grains to its surface. Look for the ring of tentacles that these animals feed with. They are able to catch small animals with the stinging cells in these tentacles, but they don't harm people.

Sea Cucumbers

Sea Cucumbers are sausage shaped animals, very common on Hawaii's reef flats. They come in various sizes and colors. A very common one can be recognized by a black, lacy, flower-like structure that sticks out of the sand. These are its feeding tentacles. Look for this structure. Poke it gently. What does it do? (It withdraws). Try to carefully dig out the animal it is attached to. You should come up with a

dark sausage shaped animal covered with sand. This is the "loli pua", or flower sea cucumber. The feeding tentacles trap food particles floating by in the current. It was probably very hard to remove this animal from the sand. Sea cucumbers are covered with many tiny suction cups (tube feet) along the ventral surface ("down" side) which they use for attachment.

As you turn over rocks you will find other kinds of "loli". Some are able to spit out white sticky threads when they are bothered. Look for a small, brown one, about 3" in length, or a beige one 6-7" long with 4-5 dark bands across the back. Pass these around for everyone to see. They may spit out their sticky white threads. Have everyone feel how sticky they are. Any animal that bothers this sea cucumber will become entangled in this mess and be unable to bother it anymore.

Activities With Sea Cucumbers

The Hawaii Nature Study Program's Reef and Shore Teacher's Guide contains a lot of information and activities involving sea cucumbers (pp. 168-172). A couple of activities that are easily done in the field follow:

1. Respiratory pulse. Sea cucumbers breathe through the anus. To see this, place a sea cucumber in a shallow pan with enough water just to cover it. As you watch it closely, you will see a stream of water come out one end. This is the respiratory current. If you pick the sea cucumber up and squeeze it gently, a stream of water will probably come out. This is the seawater inside the animal. The sea cucumber is essentially like a balloon. It has a thin body wall and is hollow inside, although it does

have digestive, respiratory and reproductive organs in there too, along with the water.

2. Feeding tentacles: Place a couple of sea cucumbers in a shallow clear plastic or glass container. Leave them alone for awhile. As they resume normal behavior, the feeding tentacles will come out of the oral end. Different sea cucumbers have different kinds of feeding tentacles. One you've seen has a black flower-like set. What other kinds do you see? Most sea cucumbers take in sand with their tentacles, and are called the "vacuum cleaners" of the reef.

3. Tube feet: It's already been mentioned that sea cucumbers have tube feed along their ventral surface for clinging to rocks. Some are able to cling more strongly than others. Sea cucumbers that live out on the reef top generally have a stronger holding capacity than those that live under rocks. Find some sea cucumbers that live in different habitats on the reef. Place them in a shallow dish. Let them sit there for 10 minutes, then gently try and lift them out. Do some cling more strongly than others? Can you relate their clinging strength to their habitat?

Brittle Stars

Brittle stars are usually found under rocks and in crevices in rocks on the reef. Usually where you find one you will find many. They are able to move very quickly when distrubed. They are not harmful in any way, and can be handled. Be careful to handle them gently, as they will drop arms off in order to get away. Hawaii Nature Study Program's Reef and Shore Teacher's Guide covers brittle stars on pp. 163-167.

Activities With Brittle Stars

1. Look for evidence of arm regeneration. The end of an arm will be much smaller than the rest of the arm.

2. How do brittle stars move? Place one in a flat shallow pan and observe. Look at arm movement and also think about the purpose of the spines on the arms. Brittle stars have the tube feet, as do sea cucumbers, but they have no suction cups on the end. Why not? (Because they are not "clingers", but fast runners.)

3. Do brittle stars prefer light or dark? Take a flat, shallow cake pan, cover one end so it is shaded. Put the brittle star in one end. What does it do? Do this a few times to see if it always shows the same behavior. What generalization can you make about its behavior in the pan and its habitat on the reef. (It should always move to the dark area.)

Sea Urchins

The commonest sea urchin you will see on the reef flat is the "ina", a small, spiny urchin that lives under rocks or in crevices and pukas in coral rocks. It is actually able to erode these holes in the soft coral rock. It is not harmful like the venomous "wana" urchin. "Ina" may be black, pink or light greyish green.

Another urchin is the pin-cushion urchin, also called short-spined urchin, "collector" urchin or "hawa'e". It is large, black and has very short spines.

The "wana" is a long spined, venomous urchin. They are easy to recognize. When they are juveniles their spines are banded black and

white. When they are adults they are large, with long spines.

Activities with Sea Urchins - pp. 158-162 - Hawaii Nature Study Program Reef and Shore Teacher's Guide

Put some urchins in a shallow, clear container. Let them resume normal activity. Sea urchins have tube feet with suction cups as do sea cucumbers. If you look carefully you will see the tiny, delicate tentacle-like tube feet extending out from the body. In the short spined urchin they are easy to see because the spines are so short. In the "ina" they are harder to see as they are about the same length as the spines. Once the tube feet have been extended they will begin to attach to the bottom and sides of the dish. If you lift an urchin gently, you will see that the tube feet are attached. These are used for respiration as well as attachment.

If you happen to find a "wana", notice that there are many tiny, thin spines among the larger spines. These are the spines that actually have venom on the tip.

Turn an urchin over to see the five tiny teeth in the center of the underside. These are for grazing on algae.

If you find a short-spined urchin, look for five pairs of rows of tube feet. Most echinoderms, like sea stars, brittle stars and sea urchins show a 5-ray plan to the body. Sea cucumbers, which are relatives, do not always show this.

Feather Duster Worms

Feather duster worms are segmented worms (annelids) that live inside tubes which they build. The feathery structures that they extend

into the water are used to absorb oxygen and trap tiny particles for food. These feathery structures are light sensitive, and can be withdrawn rapidly if the animal is alarmed by a shadow or a light touch.

Bristle or Fire-worms

These worms are also segmented worms like the feather dusters, but they do not live in a tube. They crawl around under rocks looking for prey. They can be several inches long and are usually pink. Their sides are covered with many white bristles which can cause irritation to humans if touched.

Flatworms

Flatworms are very, very flat, and just slip over the rock surface. They are not related to the segmented worms. Some are small, 3/4" long, others may be up to 2 inches long. Handle them carefully, as they are fragile. Put them in a shallow container and watch how they move. Some are swimmers, others are gliders. Flatworms eat live prey, and one kind is parasitic on oysters.

Mollusks

Cowries, cone shells, nudibranchs and sea hares are all common under rocks. Even though they look very different they have much in common. All move on a broad, muscular foot. Put them in a shallow clear dish and watch them move. Be careful of cone shells as they can sting. Handle them from the fat end and do not hold them very long. Mollusks eat a wide variety of foods, from algae and sponges to fish.

Mud or Ghost Shrimp

Look for smooth, round holes in the sandy areas. They are about ½" in diameter and are the openings for the burrows of the mud shrimp. You may see a shrimp in its hole. They have two claws, one of which is larger than the other. You may be able to see the claws and antennae, but it is almost impossible to get the shrimp out. They have a long, soft body and are quite vulnerable out of their burrows.

Questions:

1. What is a fringing reef?
2. How is it built?
3. What lives there?
4. Where do they live?
5. How are fringing reefs useful?
6. How would the surfing be in Hawaii without fringing reefs?
7. A great deal of reef area was destroyed to build the new reef runway at the airport. What do you think about this?

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AQUA-TIPS: "How-to's" for Marinating Education

LOOK "BOXES"

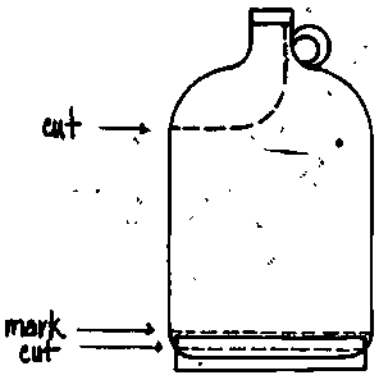
A look box that is relatively durable, inexpensive, and easy to construct consists of a plastic gallon jug with the bottom cut out and a half petri dish sealed into the hole. Half the top is cut away for viewing, leaving the handle intact for holding.

Materials

Gallon plastic jug, 1 per student or pair of students.
Silicone sealant, 1 tube for about a dozen look boxes.
Plastic disposable petri dishes, size 150mm x 15 mm; Half dish per look box (see below for source of purchase).

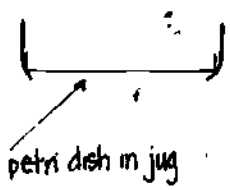
Procedure

1. Using a scissors, hack saw, and/or sharp blade, cut away half the top of a plastic gallon jug, leaving the handle as shown in the diagram.



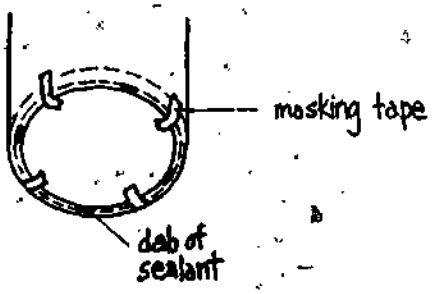
2. Set the jug on top of an open half of a petri dish. Make a mark around the jug at the top rim of the petri dish. Cut the bottom out of the jug about 1/4 inch below or inside the mark, so that the hole in the bottom of the jug will be slightly smaller than the dish.

3. Place the half petri dish inside the jug and push it toward the bottom. Hold it in place with masking or Scotch tape.

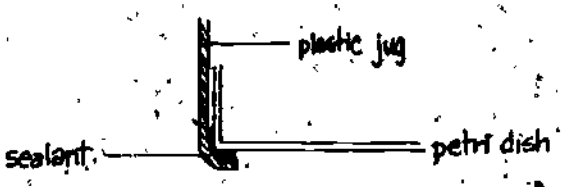


4. Apply small dabs of sealant at three or four spots around the edge to secure the position of the half petri dish in the jug. Let set for about an hour or until it becomes firm. Then remove the masking tape.

   Having the dish held firmly in place at the three or four points prevents the dish from moving or slipping when sealant is applied later. If the dish is not held firm, it slips and smears sealant across the face of the dish, obscuring the clearness of the window. Avoid touching the window with sticky fingers for the same reason.



5. With the dish held firmly by the dabs of sealant, lay a ribbon of sealant all around the crack between the half petri dish and the jug both inside and outside, smoothing it into the crevices. Carefully avoid smearing the window.



6. Allow to cure for 24 to 48 hours.

Plastic disposable petri dishes, 150 mm x 15 mm, are sold in lots of 100 dishes by Van Waters and Rogers (VWR), and in lots of 10 by X-Ray and Medical Equipment, Inc., 3160 Ualena Street, Honolulu, Hawaii 96819. The retail price was $20.00 per box of 100 dishes, which comes to 10¢ per half dish. The top half of of the dish is clear and makes a clear window in the bottom of the look box. The bottom half of one type of dish is scored in one-cm squares and provides built-in quadrats for making rough population counts.

The idea for construction of the gallon jug look box evolved during development of the Hawaii Marine Studies Science Project and the Hawaii Nature Studies Project at the Curriculum Research and Development Group, University of Hawaii.

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FIELD TRIP V - IN CLASS

FIELD TRIP V - IN-CLASS

Instructional Goal

Students will demonstrate an appreciation for the interdependence of living things in the closed earth system.

Instructional Objectives

Give examples of how survival of an organism depends on its ability to adjust to its environment.	Sc, SS, H
Explain how people make the most of their adaptations through the use of their intelligence.	Sc, SS, H, N

Performance Expectations

Uses a variety of resources to gain information on environmental matters.

Conducts simple investigations to gain first-hand information on environmental matters.

Integrates information gained from resources with information gained through direct experiences to develop understanding of environmental matters.

Essential Competencies

Reach reasoned solutions to commonly encountered problems.

Use resources for independent learning.

TOPICS DISCUSSED:

1. HABITAT DIVERSITY AND ANIMAL ADAPTATION: HOW THEY AFFECT
   A. FISH ANATOMY
   B. FISH MOVEMENT
2. FISH IDENTIFICATION
3. FISH AS A SUBJECT FOR ART

INTRODUCTION:

The extensive in-class activities described in this section provide a "hands-on" approach to understanding what a fish is and the basic similarities among different groups of fishes.[1]

Many of the variations seen among different kinds of fishes are related to their different life-styles, each species' basic body plan having evolved through countless generations to enable it to better meet the unique demands of its habitat.

TOPIC 1: HABITAT DIVERSITY AND ANIMAL ADAPTATION: HOW THEY AFFECT FISH ANATOMY AND MOVEMENT

This section includes some examples of differences in fish structures, movement and lifestyles, along with explanations of why these differences might exist. Fresh fish from the fish market, movies and slides are used in a multi-media approach to understanding fish adaptations.

[1] Grammatical note: "Fish" is plural for more than one individual of a single type of fish; "Fishes" is plural for more than one kind of fish. Example - "There are many fish in that school of aku" and "There are many fishes in the sea".

A "habitat" is the place where a living thing is normally found, and "diversity" means variety. "Habitat diversity", therefore, means the variety of places available where plants or animals can live. The term is used this way: A sandy beach has little habitat diversity, while a mountain forest has a lot. Why? (This is a good topic for class discussion before going on with further explanation.)

A sandy beach is generally composed of loose, shifting sand and only a few plants are able to grow here. Animals living here must either live in or on the sand or in the few plants. This habitat doesn't provide much variety of places to live, things to eat, nor much protective cover. A mountain forest, on the other hand, has many different places to live and the inhabitants can "make a living" in numerous different ways. There is a great diversity of plants - ferns, grasses, bamboo, bushes, trees, all of which help form the dense growth of the forest and provide many places to live. Also there is a wide variety of things to eat - different seeds, fruits, leaves, insects, etc.

When a habitat is very diverse, as for example the tropical forest, we find many different kinds of specializations among the animals that live there. The Hawaiian honeycreeper birds that live in our forests are a good land example of this, as their beaks have become adapted to be very efficient at eating very specific types of food. Some have long beaks for feeding on the nectar of flowers, others have hard, short beaks for crushing seeds, others have beaks specialized for eating certain types of insects. As these specialized adaptations to the environment evolve they help the animals compete more successfully for partic-

ular food items. This works well as long as the environment remains stable, but if it begins to change and the animals that are specialized to eat only certain things can't change, then they die out and become extinct.

A good example of this process involves the Palila, a bird found only on the island of Hawaii. This bird lives only in the mamani tree. Goats, sheep and pigs that have been introduced to this island by humans are slowly destroying this habitat, and the Palila is not able to live anywhere else. A bird that is able to eat different kinds of foods has a better chance of survival if the habitat changes, and there are many birds like this. They are the survivors in this fast changing world.

Coral reefs are in many ways like forests. They are probably the most mature environment on the earth, and they are very diverse. As corals grow they leave numerous cracks, crevices and caves - spaces deep within the reef structure, where fish and other animals can find protection for themselves and their nests. They also provide a wide variety of food - algae, living coral, plankton and other fishes and invertebrates. Since this is a diverse and stable environment, we would expect to find many different kinds of adaptations to life there. Keep in mind though, as we look at these adaptations in fishes, that many could die out if their habitats are changed through either natural or human causes.

ACTIVITY I - In-Class

Objective: To see examples of fishes that have adapted to very specific lifestyles.

Procedure: The movie "Hunters in the Reef" (F 1147B-25min.) can be obtained from the Audio-Visual Services, Sinclair Library, University of Hawaii or Department of Education Audiovisual Services Unit. Sinclair Library requires a written request three days prior to date of use.

This movie is a fairly new color movie filmed in the Red Sea. It discusses the interesting adaptations of several marine animals, while showing marine biologists in the process of understanding the intricacies of these adaptations. This is an interesting and enjoyable movie.

Another film which may be obtained through from Department of Education Audiovisual Services Unit or relevant to this material is "World Beneath the Sea".

QUESTIONS FOR CLASS DISCUSSION:

1. How do the following animals protect themselves from predators?
   a. Fish in schools (protection in numbers)
   b. Pipe or Garden eels (burrow in the sand)
   c. Amphiprion (anemone fish) (lives with stinging sea anemone)
   d. Sea urchins (spines, venom, hides)
   e. Large sea anemone (stinging cells, hides)
   f. Flatfish (flat body, camouflaged color)
2. Do both Amphiprion and the sea anemone benefit from their relationship? Explain. (Yes. Each protects the other from predators but the anemone fish probably benefits most.)
3. What did you learn in this movie about why animals have changed during the course of evolution?
   (They need to make adaptions to:
   a. avoid being eaten
   b. be able to get food.)

ACTIVITY II - IN-CLASS

Objective: To learn the parts of a fish and to see how the variations of these parts dictate lifestyles.

Materials: Provide several different kinds of small reef fishes from a fish market. (Allow $2-$10 depending on class size and time of year.) The fish market in Chinatown on the corner of King and Kekaulike Street in downtown Honolulu offers a wide variety, especially in the morning. Since fresh fish are most plentiful in the morning when teachers need to be in school, you might want to tell your local fish market what you need a couple of days ahead of time so they can have it ready for you to pick up the afternoon before its needed. It's ok if it's frozen.) A good selection would include the following:

Butterflyfish	Goatfish
Damselfish (maomao)	Small parrotfish (uhu)
Surgeonfish	Bright red fish (u'u, awoweo, ala'hi)

2 kinds of open water fish such as papio, akule, omilu or omaka
Any odd shaped fish such as rockfish (nohu), eel, flatfish or stickfish

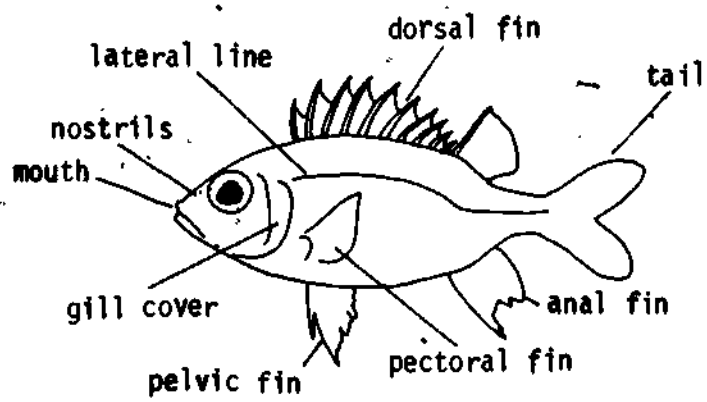
If you are not familiar with these fishes, ask the people at the market for assistance.

Procedure: You should have one fish for every 3 or 4 students. Put the fish on newspapers on the desks. Use the accompanying diagram to teach the parts of a fish. You can either reproduce this on the board or duplicate copies for each student or group of students.

Since each group has a different kind of fish, it will be necessary to involve the entire class in a discussion of each fish's differences and similarities. To do this, it is simplest to discuss the fishes by their parts.

Name the body shapes listed one by one, asking which group has an

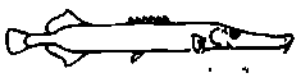
example of each. Ask the students if they can guess what the different shapes indicate about the animal's living habits (where it lives, what it eats; etc.). If a characteristic named fits a group's fish, they should write this down to be included in a report on their fish.



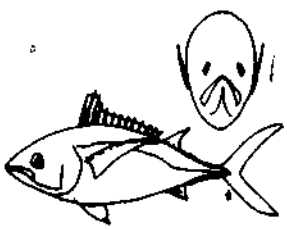
CHARACTERISTICS TO LOOK FOR:

Body Shapes:

Long and skinny like an eel: An eel's skinny, slippery body is adapted for living in crevices on the reef.



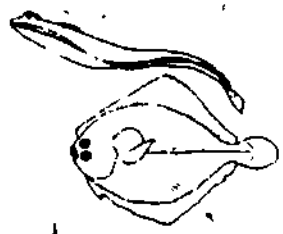
Long and skinny like a stick fish: The stickfish's long, skinny shape helps it to be unnoticed as it stalks its prey.



Oval in cross-section: Fishes that swim at least moderately fast have a torpedo shaped body that is oval in cross-section and narrowed at the base of the tail. This shape reduces friction and drag as it moves through the water.

Larger on the bottom in cross-section: Fish with this shape usually sit on the bottom. Their broad base

gives them stability and their squatness reduces the shadow they cast, thereby reducing their visibility.

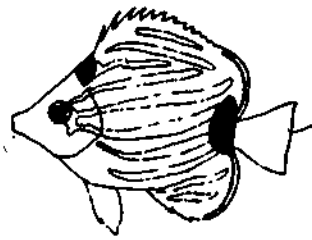


Flat body, like a flatfish: Flatfish are adapted for burying under a thin layer of sand, or blending in on the top of the sand.

High, skinny body: Fishes with this shape are able to manuever in the tight spaces of the coral reef. Also, they are hard to swallow.

Color:

Dark on the top and light on the bottom: This is a camouflage coloration (termed "counter shading") for open water fish. A fish swimming in open water is easy prey for other fish, as there is no place to hide. However, if a predator views this fish from above, its dark back will blend in with the deep blue ocean water on the bottom. If the predator is beneath it looking up, its light undersurface will blend in with the lighter sunlit water above.



Bright colors: Often, brightly colored fish have a reason for calling attention to themselves. Perhaps it is a "cleaning" wrasse (say "rass") advertising its cleaning services. Perhaps it is a way of finding a mate without making a mistake. Sometimes it is to look like another kind of fish that is avoided by predators. This is called mimicry. Big dark spots on a brightly colored fish may confuse a predator into

thinking they are the eyes of a larger fish going in the opposite direction.

Red Fish: Red is a color that shows up only in very shallow, sunlit water. It is the first color absorbed by water. Red fish appear dark in the absence of light, and most shallow-water red fish in Hawaii are night-time feeders. Many deep-water fish are also red or pink, e.g., onaga, opakapaka.

Barred Fish: Light and dark bars break up the silhouette of a fish, because they look like the streaks of shadow and light on the reef. This is called "disruptive coloration".

Mottled Fish: Mottled means to be covered with spots and streaks of different colors. Usually bottom dwelling fish are mottled in order to blend in with the bottom.

White or light colored fish: These fish usually live in sandy areas.

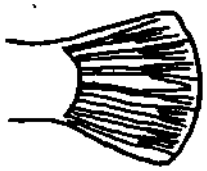
Dark Fish: Shadows on the reef help hide the dark fish.

FINS:

Tail Fin:

High forked tail: A tail like this, with a narrow reinforced base, is indicative of a fast, constantly swimming fish. Water flow over the body is enhanced by the narrow end to the body, but this narrow base

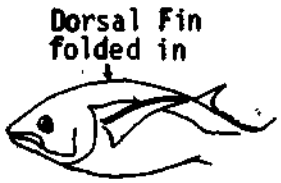
also needs to be very strong as the tail is the main method of propulsion. Look for reinforcement or "struts" here.



Wide, rounded tail: Slower fish have tails like this. Often fish with wide tails use other fins, such as the pectorals, for propulsion.

Dorsal Fin:

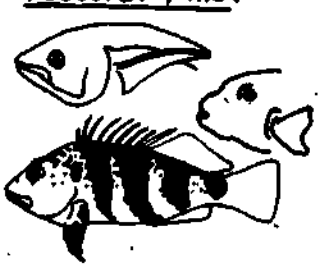
The dorsal fin in many fishes has two parts, a spiny part in front and a softer portion in the back. Press your finger along the top of this fin. You will feel the shapness of the spines in the front part. Near the back of the fin you will feel it become softer. This fin is composed of rays. Rays are generally branched at their tips and are segmented like bamboo. Look for spines and rays in other fins. There may be one or two dorsal fins.



Dorsal fins that can fold down into a slot: Fast swimming fishes are able to reduce drag by tucking in these fins.

Large fleshy dorsal fins: Slow swimming reef fishes have larger dorsal fins, and they often flare them up in encounters with other fishes.

Pectoral Fins:



Long, thin, fin: For fast steering.

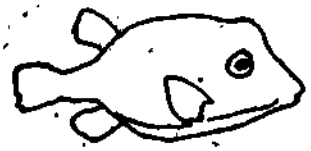
Short, wide fin: For propulsion.

Thick and fleshy fin on the bottom: For sitting on

the bottom.

No fin: Most eels lack pectoral fins.

Pelvic Fin:

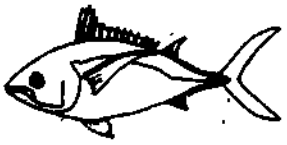


No fin: Box fish, puffers, eels

Fins modified to form a little peg or anchor: Found in trigger fish to aid them in wedging in holes.

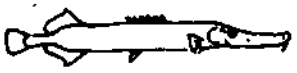
Normal: 1 spine, 5 branched rays.

Lateral Line:



Look for a thin line along the middle of the side of the fish. This is the lateral line (lateral=side), and gives the fish the ability to sense vibrations in the water. Both sound and movement travel as vibrations. Some fishes lack a lateral line.

Mouths and Teeth:



Long skinny mouth with small opening at end: These are for eating food from crevices or sucking up small animals.

Large mouth with large teeth: Usually found on fishes that eat other fishes.

Large mouth with crushing plates or molar-like teeth: For eating hard shelled animals.

Tiny, turned-up mouth: For plucking small floating animals from the plankton.

Tiny, mouth with flexible comb-like teeth: For scraping algae.

Hard beak-like mouth: For biting live or dead coral.

Gills and Gill Cover:

Look into the gill area by lifting the gill cover. Gills are red because the many tiny gill filaments contain lots of blood vessels. Oxygen from the water is absorbed by the gills to be used by the fish, and the waste products, carbon dioxide and ammonia, leave the body by the gills. Gills do the same job as our lungs as well as having a number of other functions. In fast swimming fishes like ahi and swordfish, gill filaments are fused together into a plate to prevent collapse at high swimming speeds.

Barbels:

Fish that have barbles ("chin whiskers") search for their food in the sand. Nerves in the barbels help the fish sense prey.

Spines - other than fin spines:

Spines on head or tail: These can be used for protection or in encounters with other fishes.

Scales:

No scales: Fast swimming fish appear to have no scales. Actually they are greatly reduced and can only be seen with a microscope. This is part of the general body streamlining. Many tide pool fishes and crevice dwellers lack scales to allow flexibility e.g. eels, blennies.

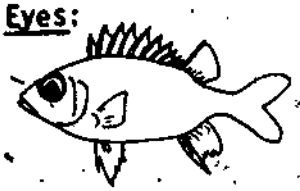
Scales: Reef fish usually have them. They help

protect the body.

Nostrils:

These are for smelling, not for breathing. Fishes usually have two pairs.

Eyes:



Usually larger in night feeding fishes.

Now that you've found all these various body parts and discussed their use, each student group should be able to write a short report about the life they think their fish leads.

ACTIVITY III: In-Class

Objective: To understand how a fish moves.

Procedure: The movie, "Fish - Master of Movement" (10 min) can be obtained from the main branch of the State Library. They will take reservations for the film up to one month ahead of the time it is to be used and will loan it for 4 days. This movie explains how the different parts of the body are used in motion by a variety of fishes.

QUESTIONS FOR CLASS DISCUSSION:

1. How is the shape of a fish adapted to move through the water efficiently?
2. What do most fishes use their tail for?
3. What do most fishes use their fins for?
4. Name some exceptions to questions 2 & 3.
5. What does a "swim" or "air" bladder do for a fish? Why is it

important? Fishes that sit on the bottom a lot often don't have one. Why?

TOPIC 2: FISH IDENTIFICATION

ACTIVITY IV: In-Class

Objective: To be able to recognize some common Hawaiian fish families.

Materials: Marine animal slides are available from your district office.

Procedure: Activity II will have heightened the student's awareness of the different shapes, colors and parts of a fish. This awareness will be reinforced during this activity.

Each slide has a number and a description of the animal shown. The following is a script using these slides, and includes information specific to the points discussed in Activity II.

Slide #	Description
146	Butterflyfishes are deep-bodied and thin and therefore hard to eat and adept at maneuvering in tight places. They are often brightly colored with yellow, black, and white. Usually there is a dark strip through the eye, perhaps to make the head less apparent.
149	Large spots on the body may act as "false" eye spots, confusing a predator about which end is the head of the fish and its size.
144	Butterflyfishes eat different things. This one plucks food from crevices.
148	This butterflyfish scrapes live coral tissue.
111	Surgeonfishes are also deep-bodied and thin and usually live close to the reef. They are often dark colored and

have a sharp spine at the base of the tail which they use aggressively against other fishes if necessary. Surgeonfishes have flexible comb-like teeth for eating algae.

109, 110 Hawkfishes sit on the bottom or on coral heads and wait for prey to come by. They have squat bodies and mottled coloration, both of which make them less visible to their prey.

126, 127 Some scorpionfishes live like Hawkfishes. They sit on the bottom and are camouflaged by their color and squat shape.

128 The leaffish is an unusual scorpionfish because it is deep bodied and lives on the bottom. It mimics a leaf wafting in the current by rocking back and forth as it sits on the bottom. Small fishes are fooled by this and are eaten when they come too close.

122-124 Anglerfishes look like lumps of colorful sponge or rocks. They too, are bottom dwellers, luring prey to themselves by wiggling their modified first dorsal spine. This spine resembles a small worm on a thin fishing pole. They show the squat bottom dwelling form with comouflage coloration.

117 Wrasses have cigar shaped bodies and broad, slow swimming tails. They usually swim with their pectoral fins. Nearly all eat benthic (bottom dwelling) invertebrates.

120 The "cleaning wrasse" is an exception to the last statement. It is highly specialized in size (small), color (bright and distinctive), and mouth structure (adapted to pluck parasites from the skin). It stays in one area on the reef, and other fish come to it to have their parasites cleaned

off. Fish do not eat this cleaner, and in other parts of the tropics other small fish mimic the size and color of this fish, and when a fish comes to be cleaned, they take a bit out of it!

132 Moray eels have elongate, slippery bodies, and usually mottled colors.

137-138 Some eels have sharp teeth for catching fishes.

141 Other eels have blunt, crushing teeth for eating animals with shells. All live in crevices in the reef.

107 The Trigger fish or "humu humu" is a slow swimming fish that dives into a hole when frightened. It has a strong spine on the top of the head above the eye which it can erect to help wedge itself tightly into its hinding place. It has a very strong head and teeth for breaking up shelled animals. Notice the absence of pelvic fins.

104-105 Pufferfishes are also slow swimmers. They protect themselves by their ability to puff themselves up to a larger size. Perhaps this discourages predators who thought they were going to eat a small fish, and suddenly find a larger fish. Also, puffers are poisonous. Some pufferfish are covered with spines (no slide). Puffers have strong crushing plates instead of teeth, and lack pelvic fins.

101 Boxfishes have hard, box-like bodies and teeth on the lower part of the head for scraping food from hard surfaces. These fish secrete a poison into the water when excited or frightened and for this reason are not good

in aquariums.

103 Cowfishes are close relatives of boxfishes and also have a hard, bony body.

114 Aweoweo is a red fish with large eyes. It hides during the day and feeds at night.

115 Squirrelfishes are also red and have large eyes. They too hide in caves during the day and come out at night to feed.

100 Eagle Rays are sting rays that spend most of their time swimming over the reef. They have hard, bony plates in their mouths for crushing bottom-dwelling animals. Other kinds of sting rays lie buried in the sand. The large Manta Ray is related to the Eagle Ray, but lacks a sharp spine at the base of the tail. Mantas eat plankton, using the large flaps next to their mouths.

ACTIVITY V - In-Class

Two new audio-visual aids about local fish ecology are available:

1. "Ecology of Coral Reef Fishes" by Edmund S. Hobson is a two-part color-sound film strip. Part 1 is 50 frames, 11 minutes; and part 2 is 44 frames, 9 minutes. This filmstrip is available through your district office.
2. "The Social Biology of Butterflyfishes" by Ernst Reese, is a 12 minutes, 16 mm sound-color film. This film is available through from Department of Education Audiovisual Services Unit. Make arrangements to borrow this film well in advance.

TOPIC 3: FISH AS A SUBJECT FOR ART

ACTIVITY VI - IN-CLASS

The fish used in Activity II can be used further.

1. You can cook and eat them;
2. You can use them in the following art activity.

Gyotaku: Fish Printing

Materials:

India or Sumi ink

Paint brushes (no. 8 or ½ inch size)

A thin absorbent paper, such as Japanese rice paper, paper towels or newsprint.

Freshly dead fish

Procedure:

1. Rinse the fish and dry it. If the fish is covered with mucus, remove it with soap and water.
2. If you want to add color to the fish print later, record where the various colors are located on the fish used in printing.

3. Brush ink completely over one side of the dry fish, but do not paint the eye. The ink should be heaviest around the edges of the fish and lightest in the center.
4. Press the paper on the inked fish, emphasizing the outline.
5. Peel the paper off carefully and let the ink dry. Add a dot for the eye and any colors you wish.

Fish printing takes some practice, but can yeild satisfying results even to beginners.

Reference: Sea World Magazine, Fall 1977.

REFERENCE

Goodson, G. (1973) The Many Splendered Fishes of Hawaii. Marquest Colorguide Books, California, 91 pp.

Gosline, W. A. and V. E. Brock (1971) Handbook of Hawaiian Fishes Hawaii Coastal Zone News, June 1978

Hobson, E., (1974) "Feeding Relationships of Teleostean Fishes on Coral Reefs in Kona, Hawaii", Fishery Bull., 72 (4) pp 915-1013

Hobson, E. and E. H. Chave, (1972) Hawaiian Reef Animals. The University Press of Hawaii, 135 pp.

Marshall, N. B., (1975) The Life of Fishes. University Books 402 pp.

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Titcomb, M. (1977) Native Use of Fish in Hawaii. University Press of Hawaii 175 pp.

FIELD TRIP VI - SEA LIFE PARK

FIELD TRIP VI - SEA LIFE PARK

Instructional Goal

Students will demonstrate an appreciation for the interdependence of living things in the closed earth system.

Instructional Objectives

Give examples of how an organism depends on its ability to adjust to its environment.	Sc, SS, H
Explain how people make the most of their adaptations through the use of their intelligence.	Sc, SS, H, N

Performance Expectations

Uses a variety of resources to gain information on environmental matters.

Conducts simple investigations to gain first-hand information on environmental matters.

Integrates information gained from resources with information gained through direct experiences to develop understanding of environmental matters.

Essential Competencies

Reach reasoned solutions to commonly encountered problems.

Use resources for independent learning.

TOPICS DISCUSSED:

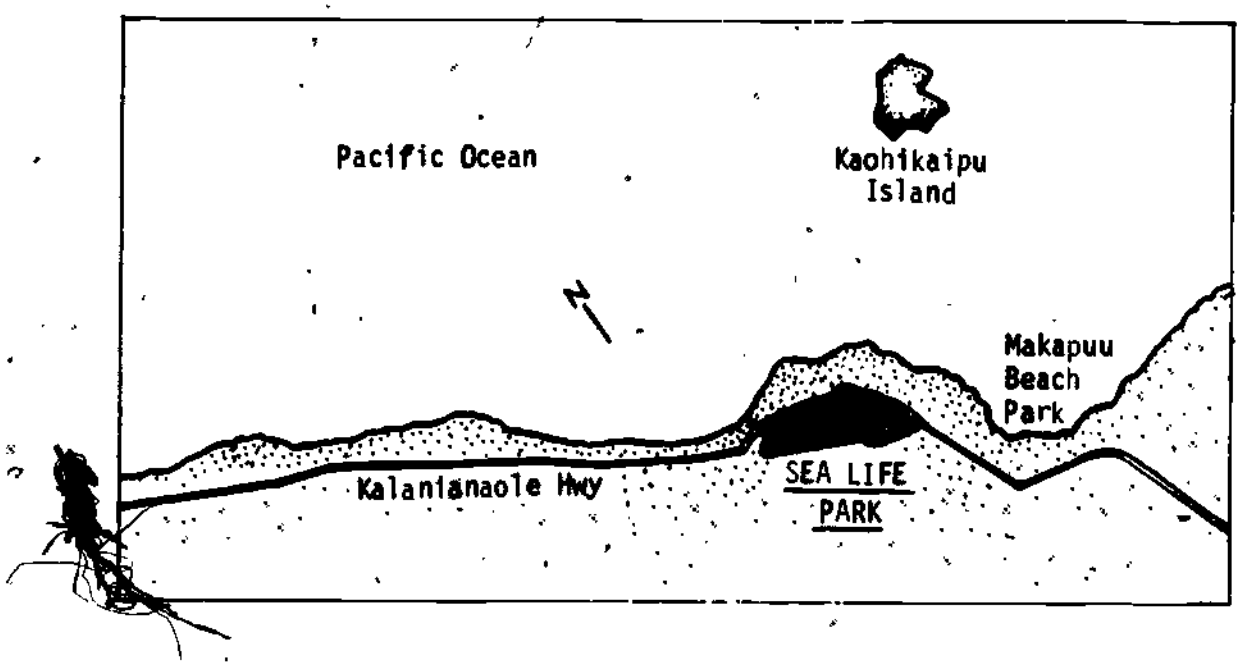
1. OBSERVATIONS OF LIVING FISHES
2. SHARKS AS FOOD

FIELD TRIP SITE:

Sea Life Park occupies a 62 acre site on the windward side of Oahu. It is located on Makapuu Point, opposite Makapuu Beach Park, on Kalanianaole Highway. The park sits on the youngest lava flow on the island.

Special arrangements can be made to visit only the reef tank for a reduced price. Call Sea Life Park's Waikiki Sales Office, 923-1531. Sea Life Park will send you a handout titled "A Student's Guide to Sea Life Park" when you book your tour.

The Park opens at 9:30 a.m. and shows in the Reef Tank are at 10:10, 12:00 and 2:00. During the show the fish are fed by a diver while information about the animals is given over the PA system.



INTRODUCTION:

The "In-Class Field Trip" was designed to teach students to make meaningful observations of fishes. Given a living fish in its natural environment, students should be able to deduce how it "makes its living"- where it lives, what and how it eats, and how it protects itself. Since a snorkeling field trip to view fishes in their natural environment is not possible for most classes, the Reef Tank at Sea Life Park will be used as an observation site.

PHYSICAL DESCRIPTION:

The reef Tank contains 300,000 gallons of water and hundreds of fishes. Water for the reef tank, and all exhibits at the park is pumped in from wells off of Makapuu Beach.

The Reef Tank is designed to provide many different reef environments including caves, sand patches, rocks, a few coral heads, arches, open water, and even tidepools. Since the tank is large and provides a diverse topography, it is possible for a fish to find a reasonably natural habitat, enhancing the students' observational efforts.

BIOLOGICAL DESCRIPTION:

The Reef Tank houses a large number and variety of Hawaiian reef fish, ranging from the tiny cleaning wrasse to large sting rays and sharks. The many colors, shapes and sizes of fishes occupying a wide variety of habitats are easily seen by students.

TOPIC 1: OBSERVATIONS OF LIVING FISHES

If the students have done the activities given in the "In-Class

Field Trip" they will be familiar with the concepts used in the following activities. If not, provide students with a sketch showing parts of a fish such as the one on page E8.

ACTIVITY I - On-site

Objective: To observe living fishes and draw conclusions about their lifestyles.

Materials: Each student should have:

1. Clipboard
2. A few sheets of both drawing and writing paper.
3. Pencil
4. Colored pens or pencils

Procedure:

Have students observe the fish in the Reef Tank for a few minutes, and then do the following:

1. Pick one reef fish in the Reef Tank and observe it for a few minutes. Do not use a shark or ray for this activity.
2. Draw a picture of it in outline both side view and cross-section.
3. Indicate which fin or fins it uses for propulsion.
4. Draw in its colors.
5. Where is it spending most of its time in the tank? (In caves, or on the bottom, high in the water, etc.)
6. Is it swimming alone or in a school?
7. What shape is the tail? What does this tell you about the fish?
8. What is the shape of the pectoral fin? What does this tell you about the fish?
9. Are there one or two dorsal fins? Do you notice the fish using the dorsal fin during encounters with other fish? (e.g. flaring it up)

10. Does the fish appear to be eating anything? (Don't count the food from the diver.)
11. Does the fish have a large or small mouth? What do you think it eats?
12. Are the eyes large or small in comparison with other fishes?
13. From your observations what can you tell about this fish's lifestyle and habitat?
14. Do you know the name of this fish or the group of fishes it belongs to? What is it about the fish that helps you recognize it?

SHARKS

1. Draw a shark.
2. Name the fins.
3. Compare the placement of the fins to the fins of the other fish you have drawn. Which ones are different? How is the shark using its lower body fins that is different from your fish?
4. How does the shark propel his body?
5. Fish that are strong swimmers have a lot of body muscle, and are usually prized food fish. Do you think sharks would be good to eat? Explain.
6. What color is the shark. Is its color more similar to reef fishes or open water fishes?
7. How many gill openings does the shark have? How many does your fish have?
8. Are there any other structures associated with the pelvic fins. (The male copulatory organs are attached to these fins.)

RAYS

1. Draw a ray.
2. How does it swim? How does its style of swimming compare to that of a shark?
3. The tail has a stinger at the base, can you see it? Draw it in.
4. How many gill openings does it have? What other fish has gill openings like this?
5. Where does this ray spend most of its time in the tank?
6. Does its color help adapt it to its habitat?

TOPIC 2: SHARKS AS FOOD

ACTIVITY II - In-class

Objective: To acquaint the students with the idea of shark as food.

Materials:

1. Obtain a copy of "Ono Hawaiian Shark Recipes" from University of Hawaii Sea Grant Marine Advisory Program.
2. Shark meat from a fish market
3. Electric frying pan
4. Food items called for in the recipe of your choice.

Procedure:

Use the "Ono Hawaiian Shark Recipes" book to introduce students to the idea of shark as food, and to find a few recipes that the class would enjoy preparing and eating. Shark meat is very good, and you should have no qualms about eating it.

REFERENCES

Tachibana, A. (Editor) "Ono Hawaiian Shark Recipes."
University of Hawaii - Sea Grant publication AB-77-03,
May, 1977.

FIELD TRIP VII - KUALOA REEF

FIELD TRIP VII - KUALOA REEF

Instructional Goal

Students will demonstrate an appreciation for the interdependence of living things in the closed earth system.

Instructional Objectives

Give examples of how survival of an organism depends on its ability to adjust to its environment.	Sc, SS; H
Explain how people make the most of their adaptations through the use of their intelligence.	Sc, SS, H, N
Collect evidence showing how the "balance of nature" has become upset with the removal (or addition) of a species from (or to) an eco-community.	Sc, SS
Explain the complexities of an ecological problem within a given ecosystem.	Sc, SS, H, LA
Identify an ecological problem in the community and design a program to correct it.	SS, Sc, H
Formulate a hypothesis about how changed environmental practices may affect the ecological balance.	SS, Sc, H
Discuss how the manipulation of one environmental element affects all elements.	SS, Sc, H
Suggest ways to guard against detrimental environmental manipulations of ecosystems.	Sc, H, LA, SS, V

Performance Expectations

Uses a variety of resources to gain information on environmental matters.

Conducts simple investigations to gain first-hand information on environmental matters.

Integrates information gained from resources with information gained through direct experiences to develop understanding of environmental matters.

Identifies state and federal governments agencies primarily concerned with environmental management or control.

Identifies non-government groups primarily concerned with environmental matters.

Describes responsibilities of state and federal agencies for environmental management or control.

Describes the functions of non-governmental groups concerned with environmental matters.

Identifies state or federal law designed to protect people and the environment and discusses their effectiveness.

Cites examples of negative and positive ways human beings can change the environment.

Identifies specific contributions one can make to help human beings live in harmony with the environment.

Essential Competencies

Reach reasoned solutions to commonly encountered problems.

Distinguish fact from opinion in TV and radio news broadcasts, advertising, newspaper and magazine articles, and public speeches.

Use resources for independent learning.

Demonstrate knowledge of the basic structure and functions of national, state, and local governments.

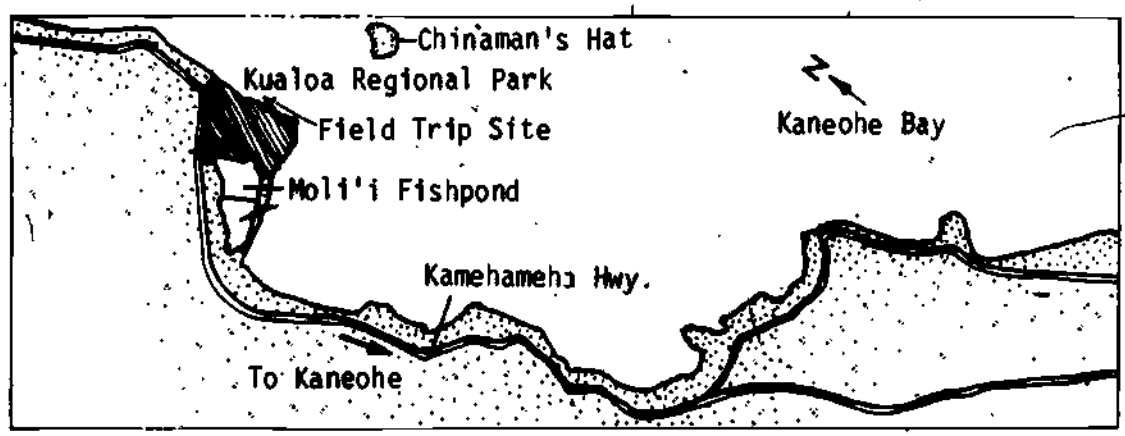
Demonstrate knowledge of important citizen rights and responsibilities.

TOPICS DISCUSSED:

1. WHAT AN ALGA IS.
2. SOME OF THE WAYS IN WHICH ALGAE DIFFER IN FORM.
3. DIFFERENT ALGAL FORMS VARY IN ABUNDANCE. SOME TYPES ARE MORE FREQUENTLY ENCOUNTERED THAN OTHERS.
4. HUMAN IMPACT, ITS EFFECT ON ALGAL POPULATIONS AND SOME OF THE WAYS THAT ALGAE ARE USED BY HUMANS.

FIELD TRIP SITE:

Kualoa Regional Beach Park is on the north end of Kaneohe Bay and can be reached from Kamehameha Highway (Highway 83). Once you turn into the park, stay on the road that parallels the beach. A large parking area is located a short distance down this road, just past the right-hand turn-off to the camping areas. The park has an extensive lawn area and a narrow sandy beach. Facilities include restrooms, showers and drinking fountains. During a low-tide of less than ½ foot, water depth near shore is less than 3 feet.



INTRODUCTION:

Algae[1] are of primary importance in the marine environment. They assume the role in the sea that terrestrial plants fill on the land; they begin the food chain. Algae are also important as reef builders and sand producers and provide habitats for many small marine animals.

In Hawaii, algae are used as food, and the word "limu" means "edible seaweed" to most people. However, the definition in the Hawaiian-English Dictionary by Pukui and Elbert is much broader, including "all kinds of plants living under water, both fresh and salt, also algae growing in any damp place in the air". In addition to their use as food, algae have also been used medicinally and in religious ceremonies by Hawaiians.

PHYSICAL DESCRIPTION:

The Kualoa Regional Park is located at the northern end of Kaneohe Bay near the old Sugar Mill ruins. It is bounded by Kamehameha Highway on the north, by the Pacific Ocean on the east, Kaneohe Bay on the south and Molii Fishpond on the west. Chinaman's Hat" (Mokoli'i) island is a short distance offshore and can be reached by foot during extreme lowtides. A broad, flat reef extends about a third of a mile offshore. A deep water channel enters Kaneohe Bay at the edge of this fringing reef, providing clean ocean water at this end of the bay.

BIOLOGICAL DESCRIPTION:

The reef at this site is extensive, shallow and moderately protected

1 "Alga" is singular and "algae" is plural.

from ocean swells. A wide variety of algae grow on the reef and many different types can often be found washed up on the beach.

TOPIC 1: WHAT AN ALGA IS

Marine algae, or seaweeds, fill the same role in the sea that terrestrial plants do on land; through the process of photosynthesis they are able to use the sun's energy to produce food for themselves, and in turn, are utilized as food by animals and humans.

Marine algae, like land plants, need sunlight, water, nutrients, upright support, and a means of distributing their reproductive products. However, since water is quite a different medium than air, marine algae are very different from land plants.

Sunlight is absorbed quickly and selectively by seawater; the longer red, orange and yellow wavelengths are removed first, leaving only the shorter blue and green. The results of this are that photosynthetic 'plants' can only live in a very narrow sunlit band near the surface of the ocean and that deeper than a few meters plants must have specialized pigments capable of utilizing the short blue and green wavelengths. This is one of the ways in which seaweeds differ from land plants.

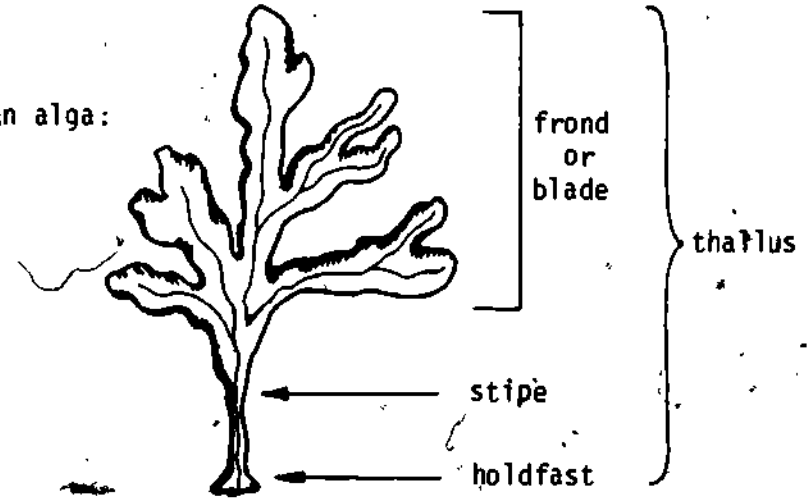
Land plants absorb water and nutrients by means of their root system. Algae lack a complex root system. Their water and nutrients are all around them, to be absorbed as needed. Algae have a structure for attachment, called a holdfast, which should not be confused with "roots".

Verticality in the marine environment is achieved by gas bladders or trapped gas bubbles providing buoyancy, or internal cellular pressure

making the algal body "turgid" or stiff.

Dispersal of reproductive products of land plants may involve bright colors, pollen, birds and bees. In contrast, reproductive products of seaweeds are shed into the sea with currents as their means of transport. Algae are adapted to a different environment than land plants, and their structures differ.

Parts of an alga:



ACTIVITY I - Pre-Field Trip

Objective: To understand the differences and similarities between algae and land plants.

Procedure: Use the preceding general information as a basis for understanding the major differences and similarities and to direct student reports and discussions. Have students present short oral reports on the following topics, and/or other related topics which seem appropriate to you.

1. What is photosynthesis?
2. What are primary producers?

3. Explain the absorption of the color spectrum in water.
4. What are plant pigments? Do algae have the same kinds as land plants?
5. How do roots work? Why don't algae have roots?
6. How do land plants reproduce? How do algae reproduce?
7. Compare the parts of a plant and the parts of an alga.

TOPIC 2: THE DIFFERENT FORMS OF ALGAE

Traditionally, the algae are divided into major groups based on their pigmentation. In many cases it would be difficult for students to decide to which group a particular alga belongs because its coloration would be deceiving. For this reason, the activities dealing with identification of algae concentrate on form and certain ecological features. A pre-field trip slide show and an identification key (see appendix) illustrate the major forms.

ACTIVITY II - Pre-Field Trip

Objective: To be acquainted with some of the various forms of algae.

Procedure: Your district office has set of slides of algae which are numbered. Use these slides to give the following introduction to algal forms. (Script prepared by Paula Busse.)

Slide #

Traditionally, the algae are divided into major groups depending on their pigmentation. The major groups include the Blue-Green, Green, Red and Brown algae. While the Green algae are most

11 always a shade of green, and the brown algae are almost a brown
58 hue, the Red and Blue-Green algae may provide some confusion.
4 This is a Blue-Green alga,
105 while this is a Red alga. In our presentation of the algae,
therefore, we will concentrate on the various forms rather than
using the more traditional approach. Some algae are fairly
116 flattened or compressed. Examples include this iridescent Red
alga,
44 this Brown alga,
35 and this Green alga. A basically flat, but 'rolled-up' alga
53 is this one.
2 Some thread-like or feather algae are this Blue-Green,
16 this green,
61 and this Brown.
Some algae are bush-like. Some good examples would be
57 this one,
63 or this
91 and this Red.
24 Some algae are hollow and tubular,
20 and still others are finger-like.
Not all algae are as smooth as those described so far.
26 Some algae are composed of segments which may be flattened
79 and bead-like, or
96 otherwise.
25 Many of the segmented algae are covered with lime. This
particular seaweed is one of the producers of beach sand.

29 This non-segmented alga is also lime encrusted.

Another grouping may include bubble-like or glob-like

7 algae. A bubble-like alga is this small sphere,

37 or this clump,

38 this individual,

22 or this cluster of bubbles.

41 This seaweed is rather glob-shaped

19 and so is this specimen.

8 We have seen but a few of the side variety of forms in the algae. When algae are collected at the Kualoa Reef site, they may be identified according to form by using the key in the appendix to that section.

ACTIVITY III - On-site

Objective: To study the varieties of marine algae found on this reef flat.

Note: This activity is designed to foster creativity and imagination. For this reason we have left the "categories" of algae that the students are looking for loosely defined. Use your own subjective judgement as to which algae fit each category and what constitutes "differences" among algae.

Conservation: Alert students to the fact that overpicking may be deleterious to the ecology of the reef; therefore, only take enough of each alga to demonstrate its characteristics.

Materials: Each group of 3 or 4 students should have the following:

1 to 4 lookboxes (see appendix of "Kewalo Basin Field Trip" for

instructions on how to make your own.)

1 clipboard

1 pencil

4 plastic bags

1 piece of paper with the following 7 categories listed.

For the whole class you should provide 7 containers (buckets or larger dishes) in which to display the collected algae. Each container should be labeled with one of the following categories:

Container #	
1.	Feathery or delicate
2.	Less than 1 inch tall
3.	Hard, crunchy or crisp
4.	Bubble-like
5.	Branches with pointed tips; bushy
6.	Flattened, fairly large (more than 5 inches tall)
7.	Hairlike (filamentous)

Procedure: Divide students into groups of 4. Give each group the above listed materials. Students should go out onto the reef and look for algae that meet the above descriptions. When they find one, they should put it in their collecting bag, transferring it to the appropriate container when they are back on shore. Give 20-30 minutes for this activity. When students are finished, go through the algae in each container and discuss the variety of types fitting each of the 7 categories. Rank the categories by the number of different algae collected (see example).

Example:

Categories	Number of different kinds of algae in container
Pointed branches, bushy	12
Hard, crunchy or crisp	8
Feathery or delicate	5
	etc.

Some algae may fit 2 or 3 categories, which is fine, as this is a subjective exercise.

Some general observations that can be made are:

1. There are many different kinds of algae
2. Some kinds are very similar
3. Some kinds are quite distinctive.

ACTIVITY IV - On-Site

Objective: To identify algae by using an "identification key".

Procedure: Using the key to some of the common algae at Kualoa Reef. (see appendix to this field trip), students should attempt to identify some of the conspicuous algal forms.

Ecological Note: Diversity

You have just collected and categorized a number of different algae. Some areas have a large number of different forms of algae or a high degree of diversity; Kualoa Reef and the reef near the Waikiki Aquarium and Natatorium are good examples. Other shorelines have a low degree of diversity or support only a few kinds of algae.

Diversity of algae on a reef of shoreline can often tell you a great deal about that environment, as different algae have different

ecological requirements (e.g. light, salinity, wave action, etc.). Also, the change in diversity over time often indicates a change in the environment, and in populated areas this change often indicates a human-made ecological disturbance (e.g. sewage, freshwater run-off, siltation, etc. See "Kaneohe Bay Field Trip" for a discussion of ecological disturbances in that bay).

TOPIC 3: DIFFERENT ALGAL FORMS VARY IN ABUNDANCE. Some types are more frequently encountered than others.

Some algae are more abundant than others in a given area. This means that they are more frequently encountered during a survey of a reef area. The activity in this section is designed to illustrate this concept.

At first glance, the idea of "abundance" may seem very elementary, but it is a very useful ecological concept. When the abundance of a certain alga changes over time, it may signal changes occurring in the environment. Abundance is interrelated with diversity (see preceding section). For a specific example of the change in abundance of an alga in Hawaii see Topic V, "Human Impact".

ACTIVITY V - Abundance

Objective: To learn that different kinds of algae vary in abundance; that at any given site some species will be very common, while others will be less common.

Materials:

1. 0.5 meter (approximately) rigid sided squares or hoops--one for each group.

2. Lookboxes-at least one for each group. (See appendix to "Kewalo Basin Field Trip" for instructions on making these.)
3.] clipborad, pencil and "Field Worksheet" for each group.
4. Hand lenses - at least one for each group.

Procedure: Select four varieties of algae that you found in activity III. Have students sketch and name the algae on the "Field Worksheet". Divide students into groups of 4. Each group should walk 5 paces into the water, place their 0.5m rigid square or hoop on the reef and look for specimens of the algae pictured on their "Field Worksheet" within this area. This will be "Sample 1". Count the patches of each of the selected algae found and record the number in the appropriate box on the worksheet. For Sample 2 walk 5 more paces seaward and again place the square or hoop on the reef. Sample 3, 4 and 5 are done the same way.

When students have finished sampling, list the total number of each kind of algae recorded at each sample site on a master "Field Worksheet". Using this master worksheet, have students answer the following questions.

Questions:

1. Which alga was most abundant overall? Least abundant?
2. Which was most abundant close to shore? Further out on the reef?
3. What are some ecological reasons why algae might vary in abundance in a given area? (wave action, salinity, depth, siltation, substratum, nutrients and chemicals in the water, etc.)

KUALOA REEF

FIELD WORKSHEET - ACTIVITY V

SAMPLE #				
1				
2				
3				
4				
5				

615

TOPIC 4: HUMAN IMPACT, ITS EFFECT ON ALGAL POPULATIONS AND SOME OF THE WAYS THAT ALGAE ARE USED BY HUMANS

This section includes an examples of "human impact", illustrated by the story of Acanthophora, an alga accidentally introduced to Hawaii in the early 1950's Also include is information on the human uses of algae as food and art.

ACANTHOPHORA

In 1952 the alga Acanthophora was found in Pearl Harbor. This was the first recorded collection of this alga from the Hawaiian Islands. In April 1953, a piece was found washed ashore at Waikiki. By May of 1953, it was abundant in Keehi Lagoon and Hauula.

Acanthophora eventually became common on the leeward coasts of Oahu. By June of 1956, it was very common in Mokuleia and a well-known botanist familiar with the reefs in that area made the following statement, "...ubiquitous some distance within the reef; observed very rare here last year. This is first time aggressive marine alga threatening native kinds" (Doty, 1961).

In a very few years, observers watched this alga spread from one site in Pearl Harbor until it encircled Oahu and increased in "frequency of observance and density of standing crop" (Doty, 1961) (i.e. it was seen more often and in larger amounts). By 1961 it had spread to Kauai and to one site on Lanai.

Where had it come from? Doty (1961) surmised it had been introduced to Oahu on the bottom of a boat, as it was previously known only from the far western Pacific (Ponape in the Eastern Caroline Islands was the

closest island to Oahu it was known from). Boat traffic had increased in Hawaii during WW II and the Korean Conflict, and it could have been brought in then. Many small introductions during the same time period possibly provided a sufficiently large inoculation to establish the species.

A heavily fouled barge, the 'Yon 146', towed to Pearl Harbor from Guam, may provide an example of the more specific type of event that led to the establishment of Acanthophora in Hawaii. One heavily 'fouled bottom' could have provided a sufficiently large inoculation for the species to become established (Doty, 1961).

The first two collections of this alga were found 12 and 30km respectively from where this barge was drydocked and her bottom scraped. This vessel was 200 ft. long and 56 ft. in beam. Growths on her hull were often 3-8" thick. This barge was also mentioned as a possible means of introduction for various fish and invertebrates. Other animals, such as jellyfish, are believed to have been introduced from the Far East on boat bottoms during WW II.

ACTIVITY VI - In-class (either pre-or post-field trip)

Objective: To learn about the consequences of introducing non-native plant and animal life to Hawaii.

Procedure: Have students find examples of other accidental or intentional introductions of non-native plants or animals to Hawaii and any known effects on the native species. (Besides the libraries, students might try the Sierra Club, Audubon Society, Dept. of Fish and Game, etc. for this type of information, see Appendix Environmental Education K-12 Curriculum Guide.) Discuss the pros and cons of these kinds

of introductions; i.e., effects of the introductions, how to prevent accidental introduction, established laws and rules regulating introductions, groups and agencies involved in regulating introductions.

ACTIVITY VII - Algae pressing

Objective: To learn the art of pressing algae. This technique can be used to make a permanent collection of algae or for art projects.

Materials:

1. Botany filler paper, available at most stationers.
2. Stiff cardboard squares, a little larger than the 8½ x 11 botany paper.
3. Cheesecloth, clean smooth cloth rags, or waxed paper.
4. Newspaper
5. Large flat pan with seawater.

Procedure:

Pressed specimens make interesting collections and are often quite attractive. Use this technique to decorate notepaper with small or delicate algae, or to press larger pieces for framing. Presses may be assembled by using cardboard squares, cloth or waxed paper and newspaper. Specimens are floated on a piece of botany paper in the flat pan, then removed and covered with cheesecloth, cloth or waxed paper. This mounted algae is sandwiched between newspaper and then cardboard. These units are then stacked and boards or other stiff material are placed on the top and bottom as reinforcement. The entire press is then weighted down heavily or tied tightly. This pressure flattens the algae as they dry. Drying will take from 4 days to two weeks. Newspaper should be changed to reduce fungal growth. Two to four days is a reasonable period between

changes. More detailed information on this process is available in Hawaiian Nature Study Program Reef and Shore Teacher's Guide, pp. 26-31.

ACTIVITY VIII - Pre-field trip

Objective: To become familiar with the algae commonly used as food in Hawaii.

Procedure: Your district office has slides of Hawaiian seaweeds. There is a set of 16 slides titled "Common Edible Hawaiian Limu". Show these to the class prior to the field trip to acquaint them with the edible types. The following are commonly found on Kualoa Reef:

1. Gracilaria coronopifolia - Limu manauea ("ogo")
2. Grateloupia filicina - Limu huluhuluwaena
3. Ulva - Limu pālahalaha or sea lettuce
4. Enteromorpha - Limu 'ele'elé
5. Laurencia - Limu mane'one'o (A favorite of the ancient Hawaiians.)
6. Dictyopteris - Limu līpoa (Unpleasant aftertaste. Used by ancient Hawaiian in time of famine.)
7. Sargassum - Limu kala (Excellent fried like potato chips.)
8. Codium (Tastes like opihi.)
9. Acanthophora
10. Hypnea - (Tastes like ogo but rather fine.)

Descriptions and sketches of these algae are available in the key in the appendix. Information regarding algae as food, algal myths, and ceremonies involving algae can also be found in LIMU and The Limu Eater (See reference section at the end of the appendix.)

ACTIVITY IX - On-site or In-class

Objective: To prepare and eat a limu dish.

Procedure: Students in your class may be familiar with limu as food or may have a family member or friend who is. If so, perhaps they would be willing to help with this activity. Equipment and supplies needed depend upon the recipe selected.

Recipes for dishes that include algae may be taken from the those cited in the appendix or from outside sources. Some of these recipes may be prepared in the field using the algae the class is likely to collect. Bon appetit.

Appendix

Key to the Algae on Kualoa Reef

Preliminary Note:

The various features of many algae may be more easily observed when the specimen has been placed in a vessel containing seawater. This is particularly true for some of the limp or finely-branched forms as it allows for the alga to spread out, etc.

In each case, choose the set of descriptors that best describe the specimen you are keying. When you have made your selection, proceed to the letter or number given to the right of that set. Sketches have been provided to assist you in making your decision where it was felt that they were needed.

COMMON SEAWEEDS *

*This section was taken from Field Keys to Common Hawaiian Marine Animals and Plants, Office of Instructional Services, General Education Branch, Department of Education, State of Hawaii, RS 80-9279

How to Use the Key

A. Examine and familiarize yourself with your specimen. Note its color, size, texture and any other outstanding features.

B. The key to green algae (in the Pictorial Key for Common Hawaiian Seaweeds) will be used as an example in this explanation. Use the first number on the left when you are told to "go to #__" in the explanation that follows.

C. Start at #1 (Green Algae, second page of key). There are two descriptions of green algae. Read both and decide which fits your specimen. In this example we will suppose it fits the first description (it is a calcareous plant as determined by the acid/bubble test). Note the number to the right of this description. In this case, it is the numeral 2, so go on to #2. Next to the number 2 is the number (1) followed by the terms, cigar-shaped, sectioned and branching, and umbrella-like. (The number in the parenthesis always indicates the description you came from; i.e. you came from the number (1) to 2 - it tells you how you got where you are and where you have been.)

D. Read the descriptions at #2 (cigar-shaped, sectioned and branching, umbrella-like). Decide which fits your plants, and note its genus. In this case, your specimen is cigar-shaped, so it is of the genus Neomeris. You have now keyed out one sample and can go on to another.

E. Again, start at the beginning of the key at #1. This time your plant is not calcareous, so go on to #3.

F. Read the descriptions at #3. Your algae is branching, so go to #5.

G. The branches of your specimen develop from a single holdfast, not a runner, so go on to #6.

H. Since your algae had flat branches and is lettuce-like, skip to #11.

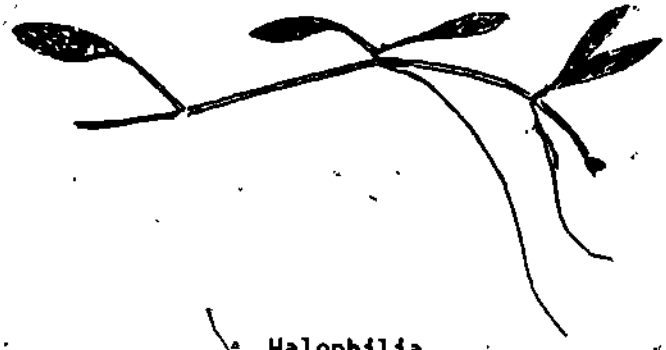
I. At #11, there is only one choice, so your plant is of the genus Ulva. Examine the drawings and decide whether your particular Ulva is one of the species shown. ("400X" means magnified 400 times; "1X" means magnified one time, or life size.)

NOTE

Most of the local species can be identified by their external morphology and their color. Some limu are hard to key, therefore, cross-section preparations are necessary. Cross-sections of algal blades or stipes can be easily cut using a razor blade. Place a piece of alga on a slide and hold it with your forefinger placed at a 45° angle to the slide. As you cut cross-sections with the razor blade, let your finger descend to lie flat on the slide. This movement will push the alga forward as you cut. Cut a dozen sections as thinly as you can. Put a few drops of water on the slide to float the cross-sections away from each other. Put a cover slip over the slide and move it gently up and down to further separate the cross-sections. Examine the sections under a microscope.

KEY TO THE MARINE PLANTS

1. Marine flowering plant.....Halophilia
   Marine algae.....2



Halophilia

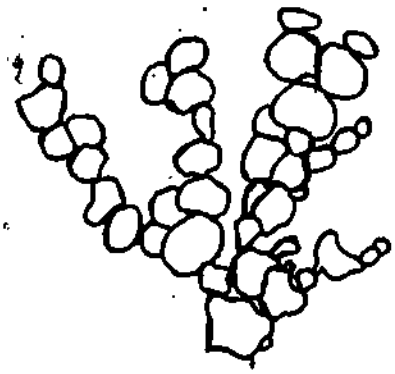
2(1) Plant green.....Green Algae.....pg. A-5
   Plant brown, sometimes with olive, greenish or yellowish casts but without pink tinges.....Brown Algae.....pg. A-10
   Plant pink or red (including Acanthophora which is brown in color).....Red Algae.....pg. A-15
   Plant hairlike, dark green or blackish.....Blue-Green Algae....pg. A-23

GREEN ALGAE

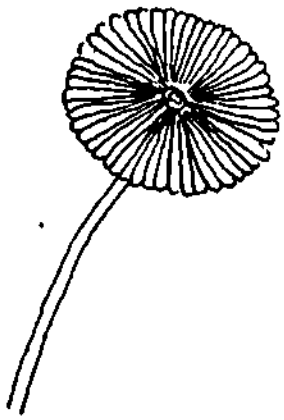
1. Plants calcareous (a crushed piece will bubble if placed in a drop of 6 normal HCL).....2
   Plants not calcareous (does not bubble).....3

2(1) Cigar-shaped.....Neomeris
   Sectioned and branching.....Halimeda
   Umbrella-like.....Acetabularia

Neomeris 10X



Halimeda 1X

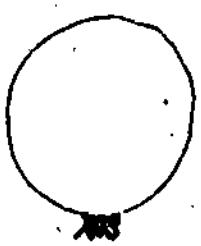


Acetabularia 6X

3(1) Plants bubble-like.....4
   Plants branching.....5

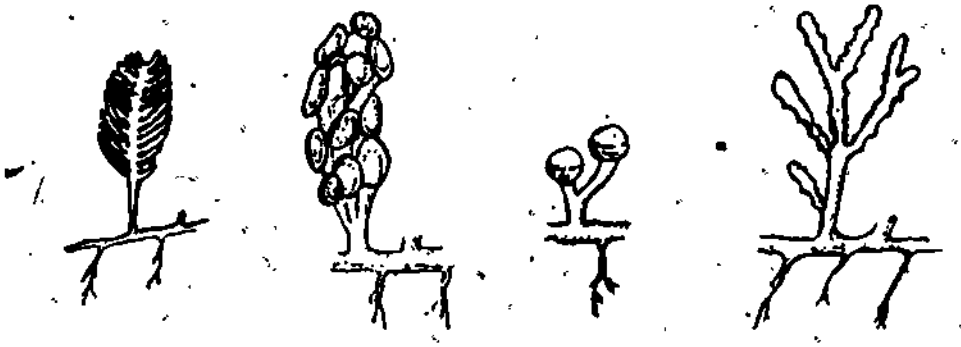
4(3) Mass of bubbles.....Dictyosphaeria
   Small single bubbles with internal stringlike supports.....Bornatella

Dictyosphaeria 1X



Bornatella 3X

5(3) Branches arise from runner (rhizome).....Caulerpa
Branches develop from a single holdfast, not a runner.....6



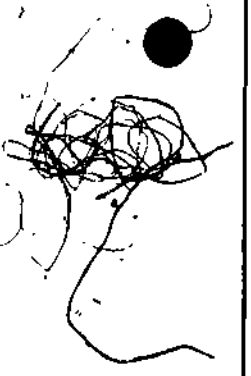
Caulerpa spp. 2X

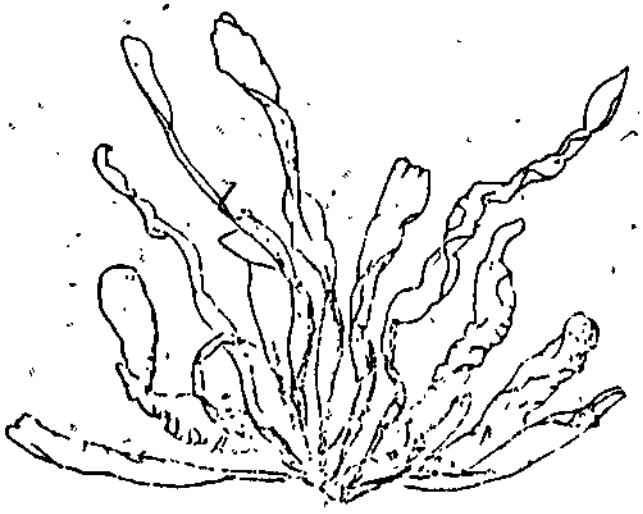
X-section 400X

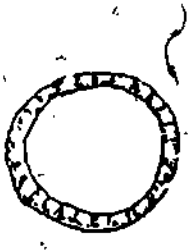
6(5) Branches hollow in cross section.....7
Branches flat, lettuce-like (X-section 2 cells thick).....11

7(6) Bubbles in blades or branches.....8
No bubbles in blades or branches.....9

8(7) Occasional bubbles, smooth blade margins.....Enteromorpha
Bubbles in each blade, margins irregular.....Siphonocladus







X-section 100X

Enteromorpha 1X

1X

10X

Siphonocladus

9(7) Plants not hairlike and in dense clumps or mats.....Valonia, Cladophoropsis, Microdictyon, Codium

Plants hairlike.....10

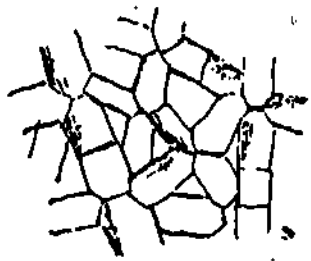
Valonia 2X

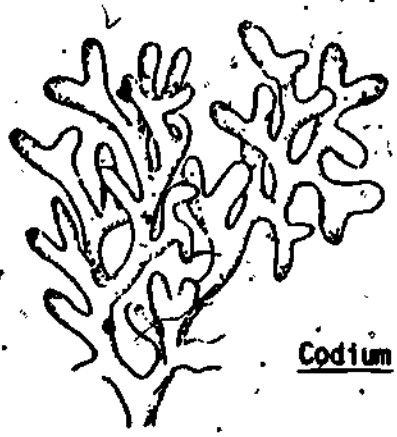
Cladophoropsis 2X

1X

Microdictyon

100X



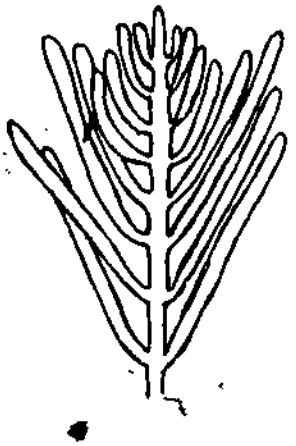


Codium 1X

"Squash Prep" 400X

10(9) Non-septate branches.....Bryopsis
Septate Branches.....Cladophora

1X



10X

Bryopsis

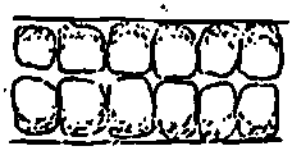
1X

10X

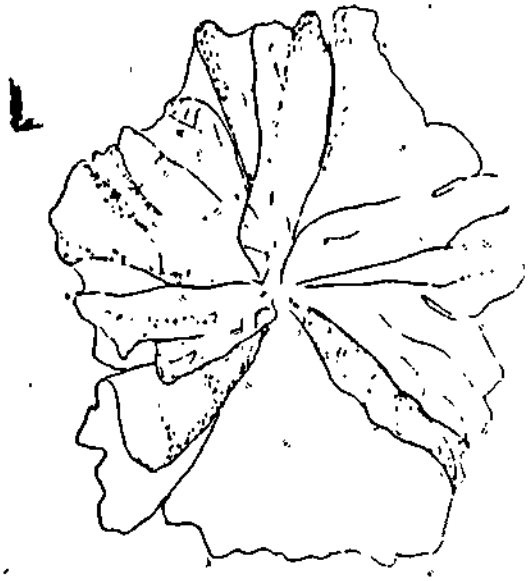
Cladophora

11(6) Branches flat, lettuce-like
(X-section 2 cells thick).....Ulva

Ulva reticulata 1X



X-section 400X



Ulva lactuca 1X

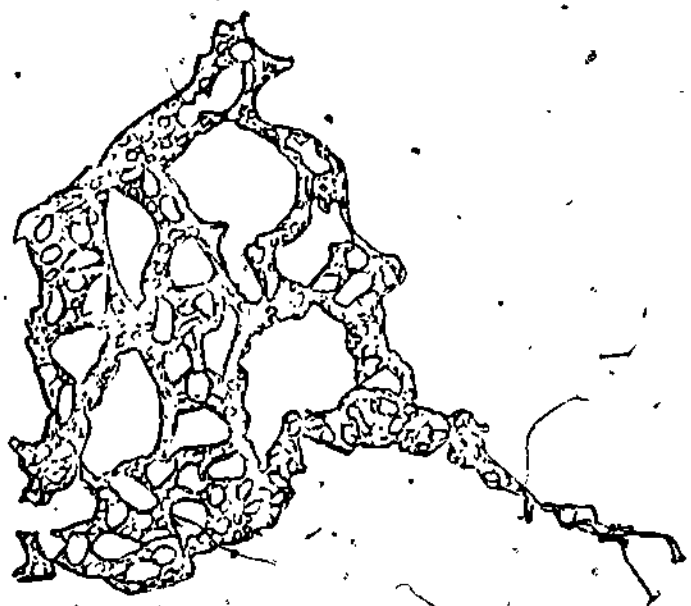
Ulva fasciata 1X

BROWN ALGAE

Plants clearly brown, sometimes with olive or greenish or yellowish casts but without any pink tinges.

1 Plants resemble hollow lumps.....2
Plants not lump-like hollow masses.....3

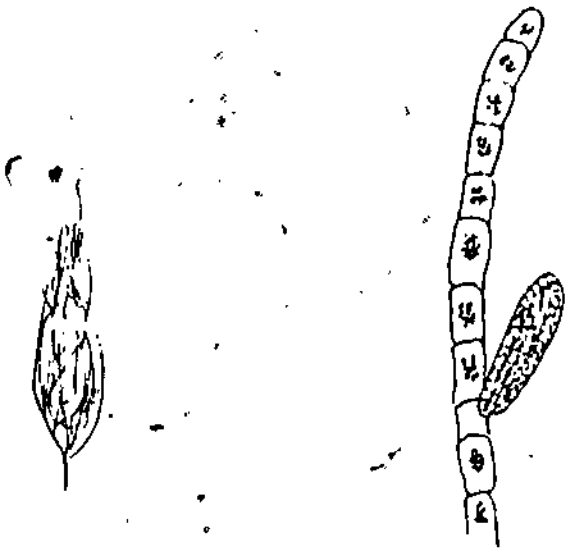
2(1). Plants look like a piece of brown swiss cheese.....Hydroclathus
Plants look like brown lumpy bubble without holes.....Colpomenia



Hydroclathrus 1X

Colpomenia 1X

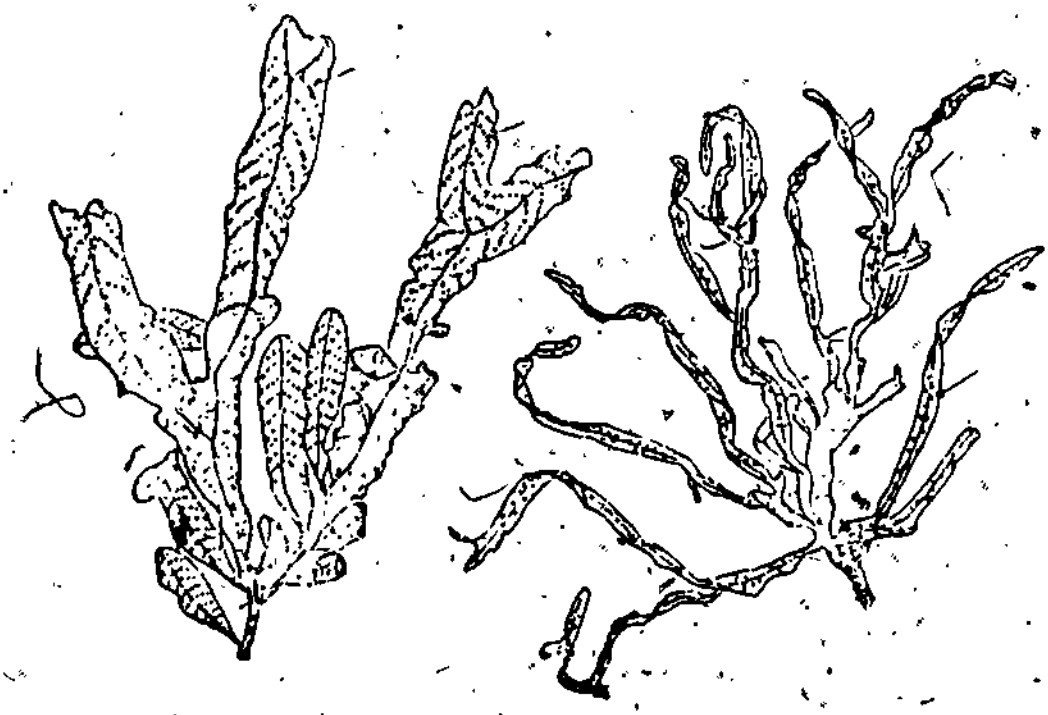
3(1) Plant hairlike.....Ectocarpus
Plant not hairlike, blades flat.....4



1X 100X

Ectocarpus

4(3) Blades with mid-ribs.....Dictyopterus
Blades lacking mid-ribs.....5

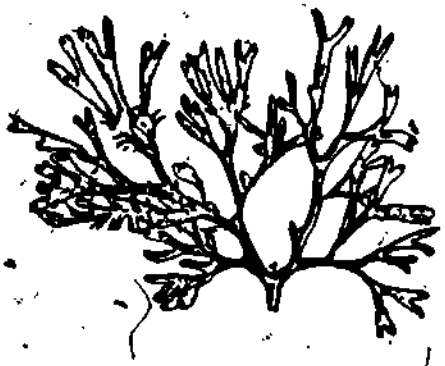


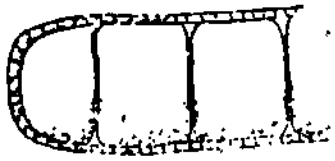
Dictyopteris australis 1X Dictyopteris plagiogramma 1X

5(4) Plant with no stem running its length.....6
Plant with a distinct stem running its length.....7

6(5) Blade with Y-shaped t[illegible].....Dictyota
Blade fanlike, calcareous.....Padina
Blade with small dark bumps.....Spatoglossum

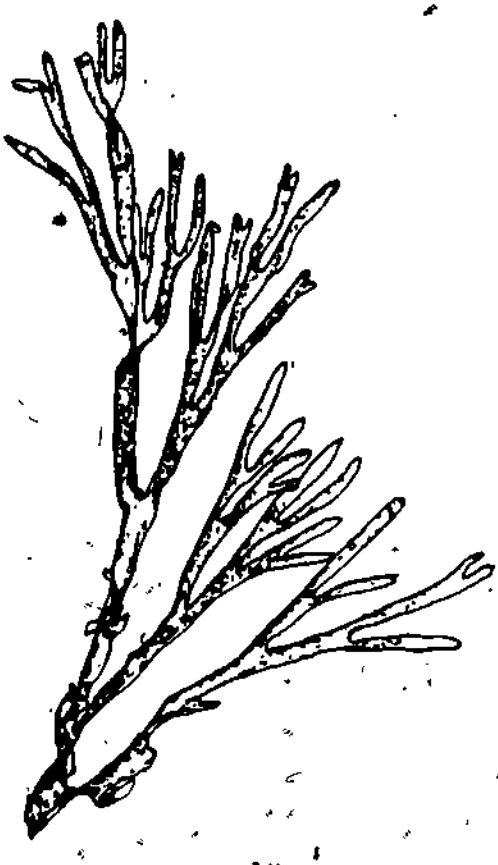
1X





X-section 100X

1X



1X

Dictyota spp.

Padina 1X

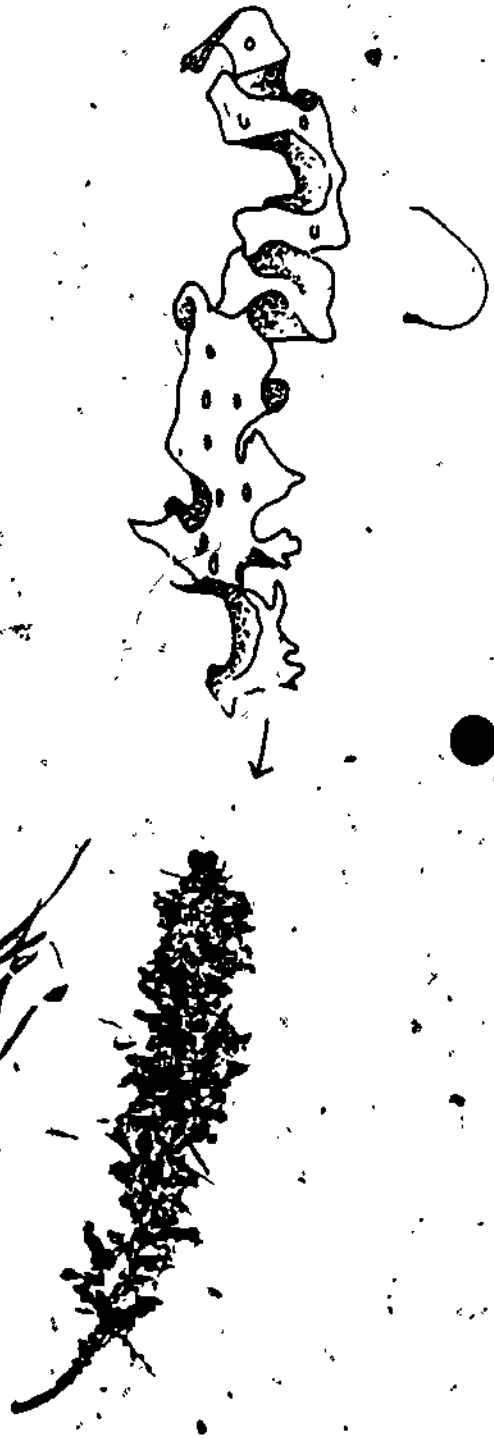
Spatoglossum 1X

7(5) Blade umbrella-like with rough edges.....Turbinaria
Blade flat, plant often with berry-like floats.....Sargassum

Turbinaria 1X

Sargassum echinocarpum 1X

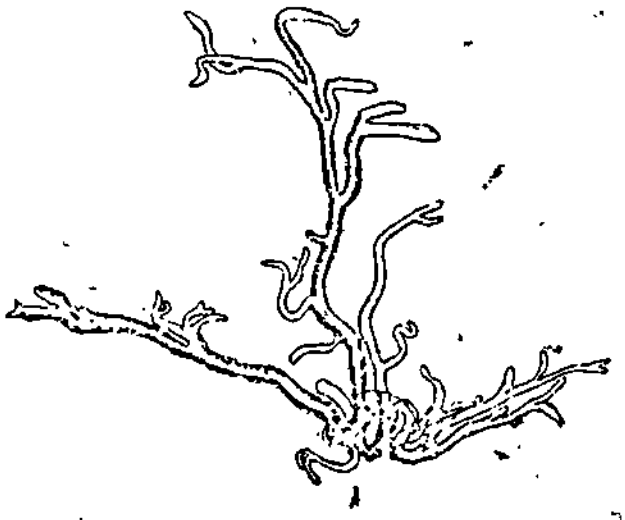
Sargassum obtusifolium 1X



Sargassum polyphyllum 1X

RED ALGAE

1	Plant gelatinous and slimy	2
	Plant not slimy	3
2(1)	Branches and blades roundish	Trichoglea
	Blades flat	Halymenia

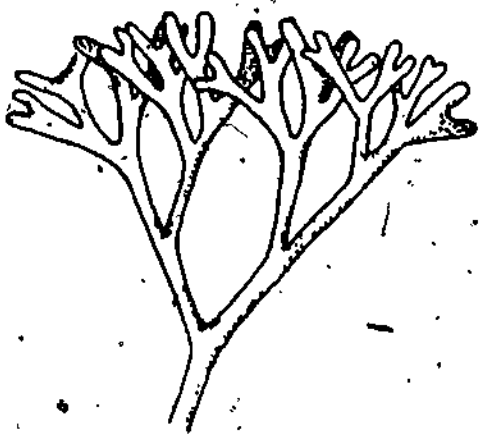


Trichoglea 1X

Halymenia 1X

3(1) Plant partially (pliable), or completely calcified (stiff); bubbles when placed in acid.....4
Plant not calcified.....7

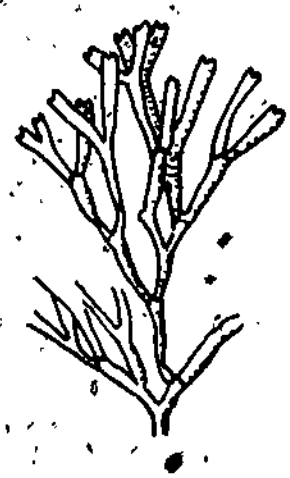
4(3) Plant non-segmented.....Gymnogongrus
Plant segmented.....5



Gymnogongrus 1X

5(4) Tip of each branch with depression.....Galaxaura
Tips lack depressions.....6

6(5) Branching is dichotomous.....Jania
Branching is pinnate.....Corallina



Galaxaura 2X

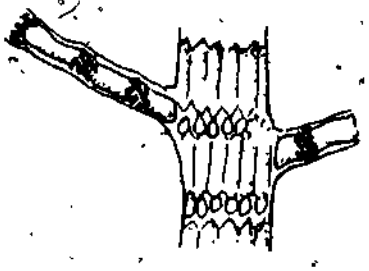
Jania 20X

Corallina 2X

7(3) Plants cylindrical in cross section.....8
Plants not cylindrical in cross section.....17

8(7) Plants with reddish band alternating with light band...9
Plants without bands:.....11

9(8) Plants not hairlike, red bands only on branches.....Spyridia
Plants hairlike, red bands on both stems and branches..10

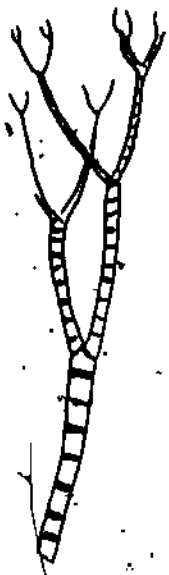


Spyridia 40X

10(9) Plant with whorls of 2 celled spines at regular intervals on stem.....Centroceras
Plant lacking whorls of 2 celled spines at regular intervals on stem.....Ceramium

Centroceras 40X

1X

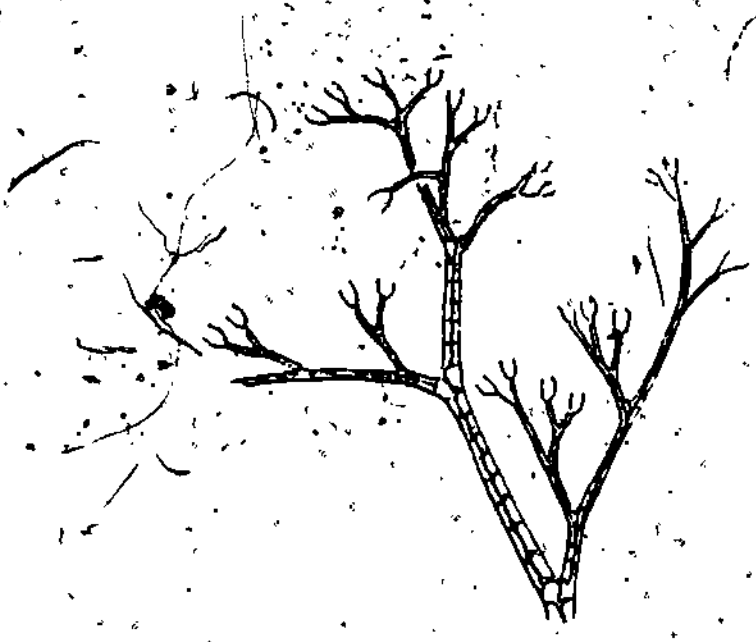


40X

Ceramium

11(8) Plant hairlike.....12
Plant not hairlike.....13

12(11) Plant made up of tiers of elongated cells of approximately equal length.....Polysiphonia
Plant not as above.....Griffithsia



Polysiphonia 20X

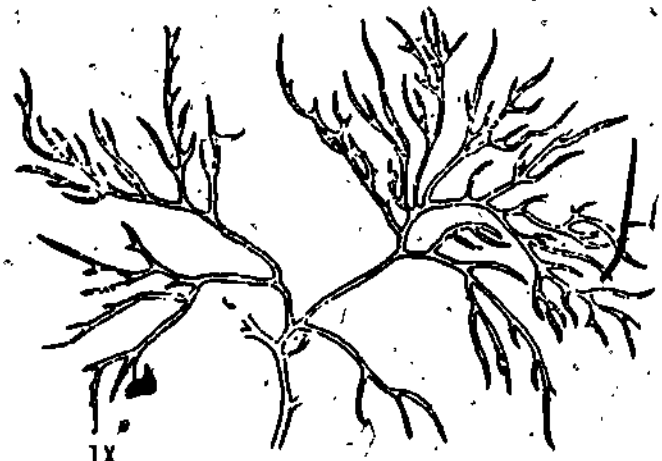
Griffithsia 20X

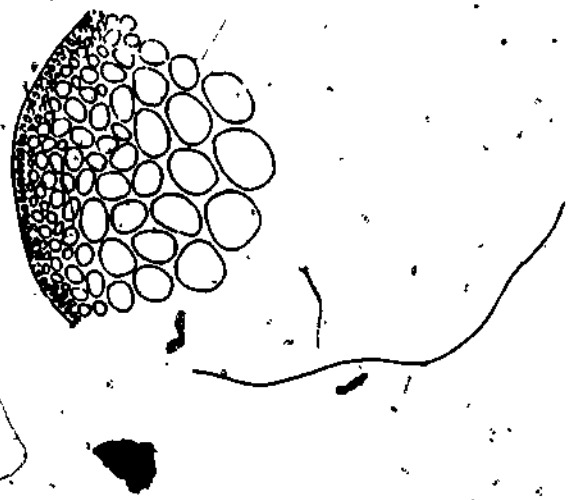
13(11) Plant with sunken pits at tips of branches.....Laurencia
Plant without sunken pits at tips.....14

Laurencia 2X

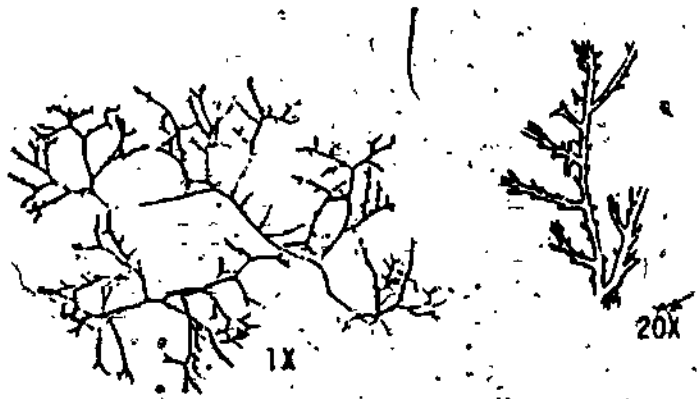
14(13) Plant with branch tips tapered to a point.....15
Plant not as above.....16

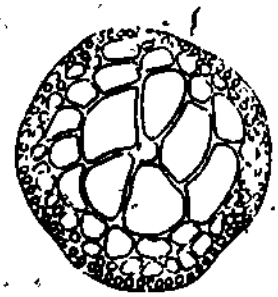
15(14) Plant with very few short branches.....Gracilaria
Plant with many shortened branches between longer ones.....Hypnea





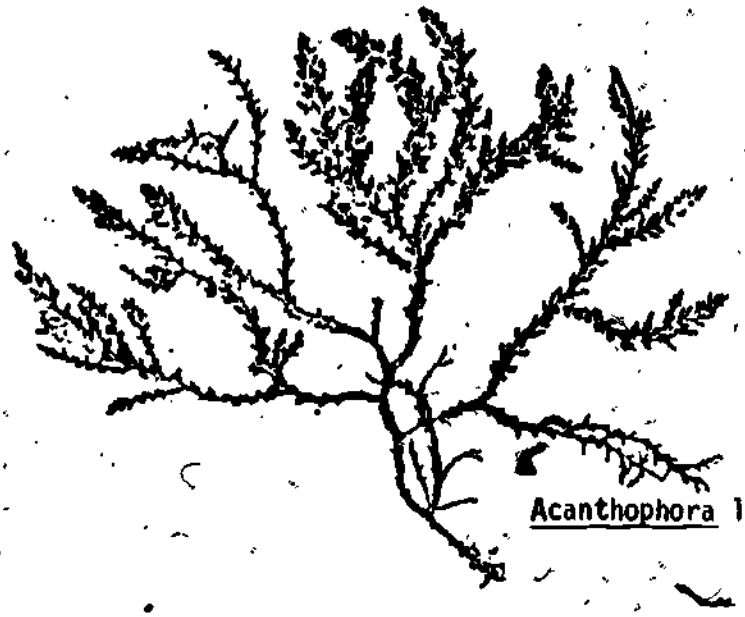
Gracilaria





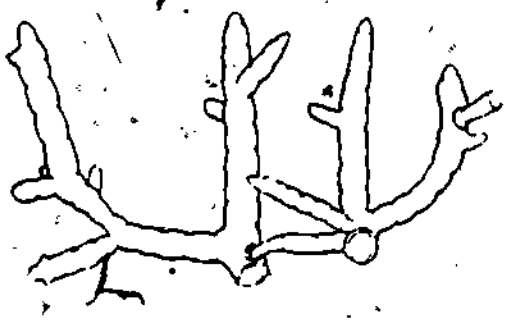
Hypnea

16(14) Plant is prickly.....Acanthophora
Plant externally constricted.....Champia
Plant vertically branching off rhizome.....Asparagopsis
Plant wiry and rigid.....Ahnfeltia



3X

Acanthophora 1X



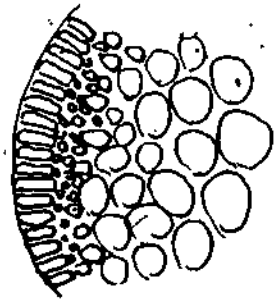
Champia 4X

1X

400X

Asparagopsis

1X



400X

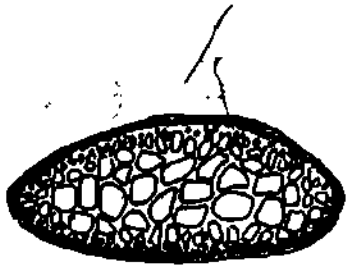
Ahnfeltia

17(7) Plant blades with ragged margins.....18
Plant blades with smooth margins.....19

18(17) Plant with blades less than 2 mm wide with recurved tips.....Desmia
Plant with blades of over 3-4 mm wide, no recurved tips.....Amansia

20X

1X



X-section 100X

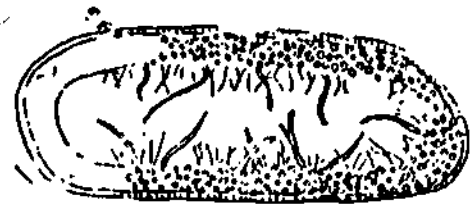
Desmia

1X

100X

Amansia

19(17) Cross section with semi-hollow interior.....Grateloupia
Cross section compact.....20

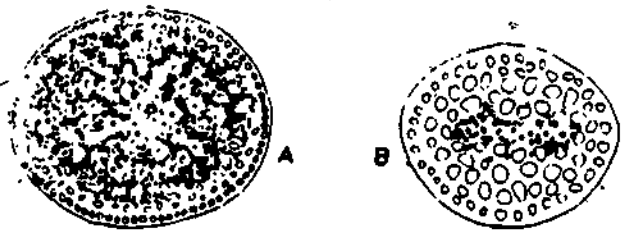


X-section 100X

1X

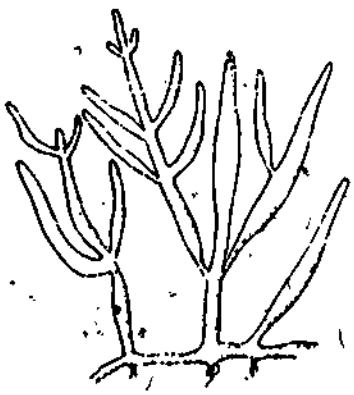
Grateloupia

20(19) Cross section with small "cells" in center.....Gelidium
Cross section without small "cells" in center.....Pterocladia



X-section 100X: A typical X-section of Gelidium stem, with the smaller "cells" packed in among the larger tissues. (A) Small "cells" in outer part. (B) Small "cells" in inner part.

Gelidium



Pterocladia 20X

BLUE-GREEN ALGAE

Hairlike algae; epiphytic or attached

Black to dark brown.....Lyngbya
Greenish spots with white and grey.....Nostoc

1X

400X

Lyngbya

1X

400X

Nostoc

Limu Recipes

Most of the Hawaiian limu are edible, except the calcium carbonate containing types. Local preferences are based on texture, taste, and availability. The recipes are basically "pickling" procedures. Boiling water is used to clean, bleach, and remove the bitter taste. (Very few limu species require this). Boiling also softens the limu. The boiling time is left to the cook.

1. Kim Chee Ogo (Korean Style)

The Hawaiian name for this limu is MANAUEA. The scientific name is Gracilaria.

1 lb. ogo
1/2 cup shoyu
1/4 cup vinegar
1 Tbsp. mirin
Ginger, grated (add to taste)
Chili pepper, grated (add to taste)
Garlic, chopped fine (add to taste)

Clean ogo, and if necessary, boil the ogo for a short time in a pot. Mix the seasonings and add to the boiled ogo. May be bottled and kept in the refrigerator.

2. Kailua Ogo

1/2 cup red wine-vinegar
1 lb. ogo
1 tsp. sugar
1 tsp. chives (diced green onions)
1/4 diced tomato
Hot sauce to taste

Follow the same directions as in the above recipe for Kim Chee Ogo.

3. Pickled Codium

The Hawaiian name for this limu is A'ALA'ULA or WAWAE'IOLE

1/2 lb. Codium
1/2 cup wine-vinegar
1/2 tsp. sugar
1/4 diced tomato

Add sauce to cleaned (using only cold water) Codium immediately before serving. Codium toughens rapidly in the sauce. Better still, try using the sauce as a "dip".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4. Limu Tsukudani: (Use on hot rice dishes)

1 lb. ogo
1 1/4 cup brown sugar
1/2 cup mirin
1 1/4 cup shoyu
1/4 tsp. MSG

Clean limu. Bring sugar, shoyu, and mirin to a full boil. Place cleaned limu into pan and cover with sauce, and cook to a "mush" (Be careful that it doesn't burn; stir frequently). Goma (sesame seeds) and chili pepper may be added to taste.

Suggested Readings

Arnold, A.F.	1968	The Sea-Beach at Ebb Tide. Dover Publications, Inc., New York.
Daws, D.J.	1967	Marine Algae in the Vicinity of Tampa Bay, Florida. University of South Florida
Dawson, E.Y.	1956	How to Know the Seaweeds. Wm. C. Brown Co.
	1966	Marine Botany: An Introduction. Holt, Rinehart, Inc.
Fritsch, F.E.	1935	Structure and Reproduction of the Algae. Cambridge University Press
Littler, M.M.	1971	Roles of Hawaiian Crustose Coralline Algae (Rhodophyta) In Reef Biology. PhD Thesis, University of Hawaii.
Neal, M.C.	1930	Hawaiian Marine Algae. Bishop Museum Bull. 67
Reed, M.	1907	The Economic Seaweeds of Hawaii and their Food Value. Annual Report of the Hawaii Agricultural Experiment Station for 1906.
Magruder, W.H. and Hunt, J.W.	1979	Seaweeds of Hawaii. The Oriental Publishing Co., Honolulu, Hawaii.

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Abbott, I. A. and E. H. Williamson (1974), LIMU, An Ethnobotanical Study of Some Edible Hawaiian Seaweeds. Pacific Tropical Botanical Garden Kauai, 20 pp.

Dawson, E. Y. 1966), Marine Botany, Holt, Rinehart and Winston, Inc., New York, 371 pp.

Doty, M. S. (1961), Acanthophora, A Possible Invader of the Marine Flora of Hawaii, Pacific Science, 15:4, pp. 547-552.

Office of Instructional Services, General Education Branch, Department of Education, Field Keys to Common Hawaiian Marine Animals and Plants, State of Hawaii, RS 80-9279, May 1980.

Fortner, Heather, (1979) The Limu Eater, Sea Grant Office, University of Hawaii.

Hawaii Nature Study Program Reef and Shore Teacher's Guide, Building 3, Room 225, Curriculum Research and Development Group, University of Hawaii, 1776 University Avenue, Honolulu, Hawaii 96822, Phone 948-7793.

Magruder, William H. and Hunt, Jeffrey W. (1979) Seaweeds of Hawaii, The Oriental Publishing Co. 115 pp.

FIELD TRIP VIII - WAIKIKI AQUARIUM

FIELD TRIP VIII - WAIKIKI AQUARIUM

Instructional Goals

When faced with decisions concerning the use of terrestrial and extraterrestrial resources, students will select practices developed in recognition of present and future environmental and human needs. Students will demonstrate an appreciation for the interdependence of living things in the closed earth system.

Instructional Objectives

Explain why algae and coral are renewable resources and discuss the constraints on this renewability.	Sc, SS
Discuss the economic value of coral in Hawaii.	Sc, SS, M, C
Identify industrial practices which minimize detrimental impacts on the environment.	SS, Sc, H, BPA, C

Performance Expectations

Uses a variety of resources to gain information on environmental matters.

Integrates information gained from resources with information gained through direct experiences to develop understanding of environmental matters.

Describes the natural resources needed by various industries and relates the locations of those industries to available resources.

Describes the impact of various industries on the environment.

Essential Competencies

Reach reasoned solutions to commonly encountered problems.

Use resources for independent learning.

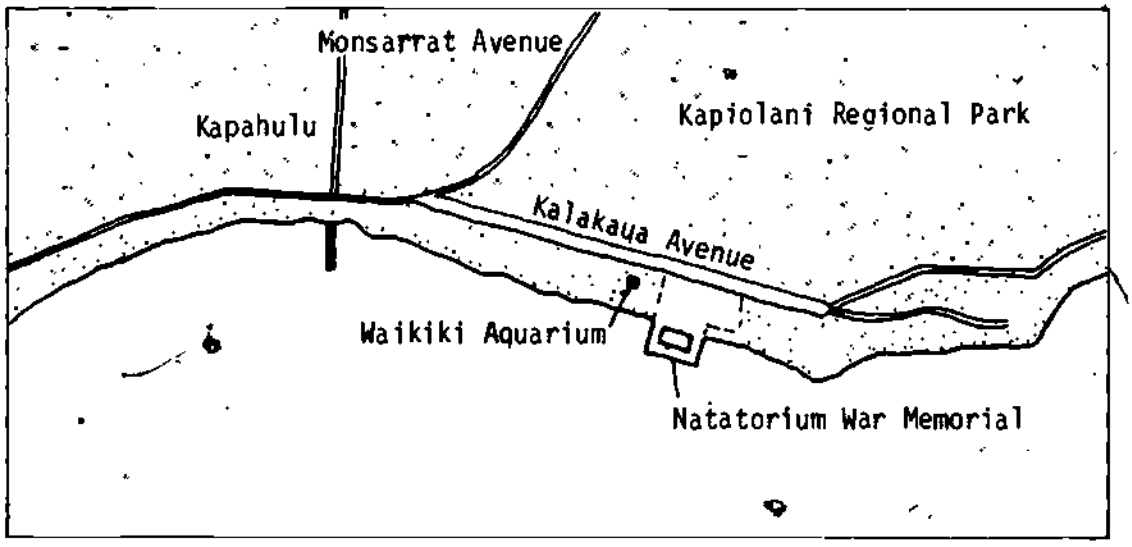
Identify the training, skill and background requirements of at least one occupation in which the student is interested.

TOPICS DISCUSSED:

1. WHAT ARE "PRECIOUS CORALS"?
2. HARVESTING PRECIOUS CORALS
3. MANUFACTURE OF PRECIOUS CORAL JEWLERY
4. VOCATIONAL OPPORTUNITIES IN THE PRECIOUS CORAL INDUSTRY.

FIELD TRIP SITE:

The Waikiki Aquarium is on Kalakaua Avenue in Kapiolani Park. It is part of the University of Hawaii and is open to the public every day from 10 a.m. to 5 p.m. The Aquarium has an active school tour program with various topics for all grade levels, and there is no charge for this service. To make arrangements for the "Precious Coral Tour" call 923-4725. This tour consists of a slide talk on the harvesting of precious corals and an examination of a display on types of corals used in jewelry and the jewelry making process.



INTRODUCTION:

Precious corals form the basis of an innovative and profitable new industry for Hawaii; however, neither the beds of precious coral nor the factories where the jewelry is made lend themselves to school trips. For this reason, the Waikiki Aquarium, in cooperation with Maui Divers, has developed a display about these corals.

Recently, a small, well-illustrated book on precious corals has become available, and this book, in combination with a tour of the Aquarium, a trip to a jewelry store, and other information provided here, should give your class an idea of what this industry is all about.

TOPIC 1- WHAT ARE "PRECIOUS CORALS"?

ACTIVITY 1 - Pre-Field Trip: In-Class

Objective: To understand what corals are.

Materials:

1. Film strip by Dr. Art Reed on corals, available from your District Office, "Living Coral: How it Grows and Reproduces"
2. Hawaii's Precious Corals by Dr. Richard Grigg, available in libraries or bookstores.

Procedure: The film strip and Hawaii's Precious Corals (Ch. 3), describe what corals are and how precious corals are different from yet similar to reef-building corals.

Have students answer the following questions, using the above material as reference.

1. Why are precious corals used for jewelry while reef corals

are not? (Precious corals are hard and non-porous.)

2. Why can precious corals live at great depths while reef corals cannot? (Precious corals don't have zooxanthellae.)
3. Where is the living part of the coral? What is different about where the polyps live in precious corals and reef corals? (The polyps of reef corals sit in depressions in the calcium carbonate skeleton. These "cups" make the reef corals porous. The skeletons of the precious corals used in jewelry do not have these depressions, making the skeleton smooth and hard. The living material forms a thin skin over this skeleton.)

TOPIC 2 - HARVESTING PRECIOUS CORALS

ACTIVITY II - Pre-Field Trip: In-Class

Objective: To appreciate the excitement of viewing precious coral.

Materials: Hawaii's Precious Corals, Ch. 1

Procedure: Chapter one is an exciting first-hand account of the initial dive in a two-man submarine to view the precious coral beds off Makapuu Point, Oahu.

As a project, have a group of students prepare an oral reading of this fascinating adventure.

ACTIVITY III - Pre-Field Trip; In-Class

Objective: To learn about the harvesting and conservation of precious coral.

Materials: Hawaii's Precious Corals, Ch. 4 and 5

Procedure: Students could read this information and answer the following questions, or this could be the basis of a student oral report.

1. How has precious coral been harvested in the past?
2. How is it harvested in Hawaii?
3. Do you think one way is better than another? Explain.

ACTIVITY IV - On-Site

Objective: To learn about the various methods of harvesting the different precious corals.

Procedure: This slide talk will be given at the Waikiki Aquarium. (see "Field Trip Site"). It will cover the biology and harvesting of black coral by divers off Maui and the harvesting of pink and gold coral by the Star II submersible in the Makapuu beds.

TOPIC 3 - MANUFACTURE OF PRECIOUS CORAL JEWELRY

Maui Divers is unique to the jewelry industry. Remarkably self-sufficient, they harvest the coral, design and manufacture the jewelry, develop and build most of the machines used in jewelry production, and market the finished product. Of the 316 people that currently work for Maui Divers, 216 are involved in the manufacture of the jewelry.

The designing of each piece of jewelry is the first step in its production. Maui Divers employs 19 designing goldsmiths to do this important job. Well-trained and creative goldsmiths are difficult to find, and Maui Divers recruits world-wide to fill these

positions. The designing goldsmiths create new jewelry styles and hand make the one-of-a-kind pieces for the "Designer" collection.

Once a jewelry design is selected for production it passes through many steps which will be explained at the Waikiki Aquarium. During these steps the gold is formed into mountings, and the coral is shaped as required. The mounting then requires extensive and careful finishing and is finally set with the coral.

Maui Divers has had to develop much of its own machinery for the shaping of the coral and the mountings. Experimental machinists are responsible for the design and building of this sophisticated machinery, and like the designing goldsmiths, people with these creative and highly developed skills are difficult to find.

How do people on the production line know which styles to make in order to efficiently meet the demand? Maui Divers has its own computer and computer programmers. Orders from each store are entered into the computer each day. The resulting print-out determines the number and styles of jewelry to be made the next day.

Maui Divers guarantees its jewelry for life and puts a lot of energy into producing a quality product. Employees are rated for their productivity and the quality of their work, and those who rate highly in these areas receive a higher hourly wage when their pay scales are adjusted during periodic reviews. The jewelry usually associated with Maui Divers are the "Line" items. These are the production line pieces. The "Designer" collection consists of handmade, one-of-a-kind pieces which are usually larger and heavier than the "Line" items. They contain more gold, substantial pieces of coral and are often

set with diamonds and other precious stones.

ACTIVITY V - On-Site

Objective: To understand the jewelry making process.

Procedure: The Aquarium has a display on this process which will be explained by a "docent" (volunteer tour guide).

ACTIVITY VI - On-Site

Objective: To see the range of precious coral jewelry available in the stores and to become an informed potential consumer of this product.

Materials: Paper and pencil

Procedure: The "Coral Grotto" jewelry stores carry Maui Divers jewelry. One of these stores is in the Hyatt Regency Hotel (Hemmeter Center), a 15 minute walk from the Aquarium. The store manager has kindly consented to have students come in, view the jewelry and ask questions. Because the store is small, she requests that 10 or less students be in the store at one time. She also requests that teachers wishing to bring their class to the store call a day or two ahead of time to inform the store personnel. Phone 923-3454.

To find the "Coral Grotto", enter the Hyatt Regency through the Diamond Head entrance. Walk through the breezeway towards the waterfall in the center of the hotel complex. The shop is on the left, before the waterfall.

Have students do the following:

1. Once inside the store, determine which displays represent the "Line" items and the "Designer" collection. You will

see other pieces of jewelry and jeweled coconut trees decorated with chips of pink coral and olivine. These form the "Pele" collection. Pieces of coral too small for use in the more expensive jewelry are used here, instead of being wasted. Just by looking at them decide how the jewelry in these three collections differ. How do their price ranges vary?

2. Find representatives of black, pink and gold coral jewelry. Which type of coral shows the greatest color range?
3. Are all colors of pink coral used in the "Designer" collection? All colors of gold coral?
4. Ask the sales clerk to show you the "Angelskin" Grading Board. This shows the color range of pink coral. How does the color influence the price?.
5. Find pieces of "Line" items that have been "inlaid". Ask the salesclerk for help if necessary. How do these compare in price to other pieces of similar size?

ACTIVITY VII - Post-Field Trip, In-Class

Objective: To design a piece of coral jewelry.

Procedure: Have students design and draw a piece of coral jewelry.

TOPIC 4 - VOCATIONAL OPPORTUNITIES IN THE PRECIOUS CORAL INDUSTRY.

The vocational opportunities in the precious coral industry are varied and expanding. Maui Divers hires people with a wide variety of skills. They are also an innovative, fast-growing, Hawaii-based company.

Most of the jobs with this company involve the making of jewelry and the handling of costly material. Maui Divers requires that people applying for jobs have previous successful work experience handling items or products of value or excellent character references. Also important for people in the jewelry making process are good eyesight and finger dexterity. Most of the production line work involves careful handling and manipulating of various parts of the jewelry as it goes through the many processes required to turn out a quality product.

The least skilled employees on the production line begin at near minimum wage with raises at 3,6,12,18,24,30, and 36 months. The employee's work is rated by the supervisor. More highly skilled employees, such as jewelry designers, experimental machinists, computer programmers, accountants and managers, start higher in the pay structure.

Maui Divers offers many benefits for its employees, such as a fully paid medical and dental plan, free life insurance, free pension plan, 40 hours of paid sick leave a year, a subsidized cafeteria, and paid vacations ranging from 2 to 4 weeks a year, depending on lenoth of employment. An incentive program rewards employees for recruiting people for job openings, for exceptional jewelry designs and for unused sick leave. The company also pays for the education of its employees if it relates to their jobs. For example, the company pays for classes in management, accounting and shorthand, at a cost of $95 per student per class and for classes in jewelry design at $295.00 per student. Most of the employees in managerial positions have moved up within the company, rather than being brought in from the outside. The free education plan helps teach them the skills necessary to suc-

ceed in their new positions.

If a person is interested in becoming a jewelry designer he/she can enter the company as a traninee, or after training at the Gemological Institute in Santa Monica, CA or other similar schools, or after training with other jewelry making firms. Jewelry designers are recruited world-wide.

Another job requiring skill and experience is that of Research and Development Experimental Machinist. These are the people that design and build the machines to make the jewelry. Newer jewelry designs involve inlaid coral, and required the development of machines to do the precision cutting on both the gold mounting and the coral.

As of September, 1978, Maui Divers employed 216 people in manufacturing, 33 in administration, 59 in sales and marketing, and 8 in deep exploration. This was a total of 316 people, of which 100 were hired during 1978. In 1977 the company grossed $7 million. In 1978 it grossed $10 million. By 1982, the company hopes to employ a staff of 1500 and gross $100 million.

Questions for students:

1. If you were to work for Maui Divers, what kind of job would you prefer? What kind of training would you need for this job? How would you get it?
2. Maui Divers has plans for extensive growth. What could limit this growth?
3. Is Maui Divers the kind of industry you like to see in Hawaii? Explain.
4. Do you think it's important that a company offer extensive

fringe benefits to its employees? Would you rather have a higher hourly wage than fringe benefits? Explain.

5. As an extra project, look into the pay scales and fringe benefits offered by several other companies of comparable size.
6. Do you think it is advantageous for a company to be largely self-sufficient (like Maui Divers)? Make a list of the advantages and disadvantages.

REFERENCES:

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Grigg, Richard, "Hawaii's Precious Corals", National Geographic Magazine, May, 1979, Vol. 155, No. 5 pp. 719-732.

FINAL APPENDIX

Tidal Information

Information about tides is essential for planning some of your field trips. If you anticipate shoreline field trips for the school year, you will want to know the times that tides occur well in advance. For this long-range planning, the tide tables printed by the U.S. Department of Commerce are useful. Ask for Tide Tables 19 , Central and Western Pacific Ocean and Indian Ocean. These tables show the times and heights of the high and low tides for the Honolulu reference station. Predictions are given for each high and low tide for every day of the year. The date is listed and the day of the week abbreviated underneath. The four daily tides are listed consecutively with the time given in hours and minutes (24 hour clock) and the height given in feet and meters. To change the time between 1300 and 2400 to conventional time, subtract 12 hours. Thus, 1949 less 1200 becomes 749, or 7:49 p.m. All times adjusted this way will be p.m.

The tides occur at different times around the island, but the data is given only for the Honolulu reference station; therefore, adjustments must be made for the tides in other areas. This time difference is charted on the accompanying map of Oahu. A "plus" in front of the time given means that the tide occurs later, so that the amount of time given must be added to the Honolulu time. If a "minus" is shown, the tide occurs earlier, and that amount of time should be subtracted from the time in the table. For example, a low tide in Honolulu at 12:00 noon would occur 1 hour and 21 minutes earlier in Kaneohe Bay, or at 10:39 a.m. This same low tide would occur 15 minutes later in Waianae than it did in Honolulu, or at 12:15 p.m.

*Check in the yellow pages of the Hawaiian Telephone Directory under "Charts" for purchase information. The daily and weekend newspapers also contains weekly tide information in the weather section.

"Good" or "extreme" low tides are those between +0.2 ft. and -0.3 ft. The best time of the year for these tides is Spring.

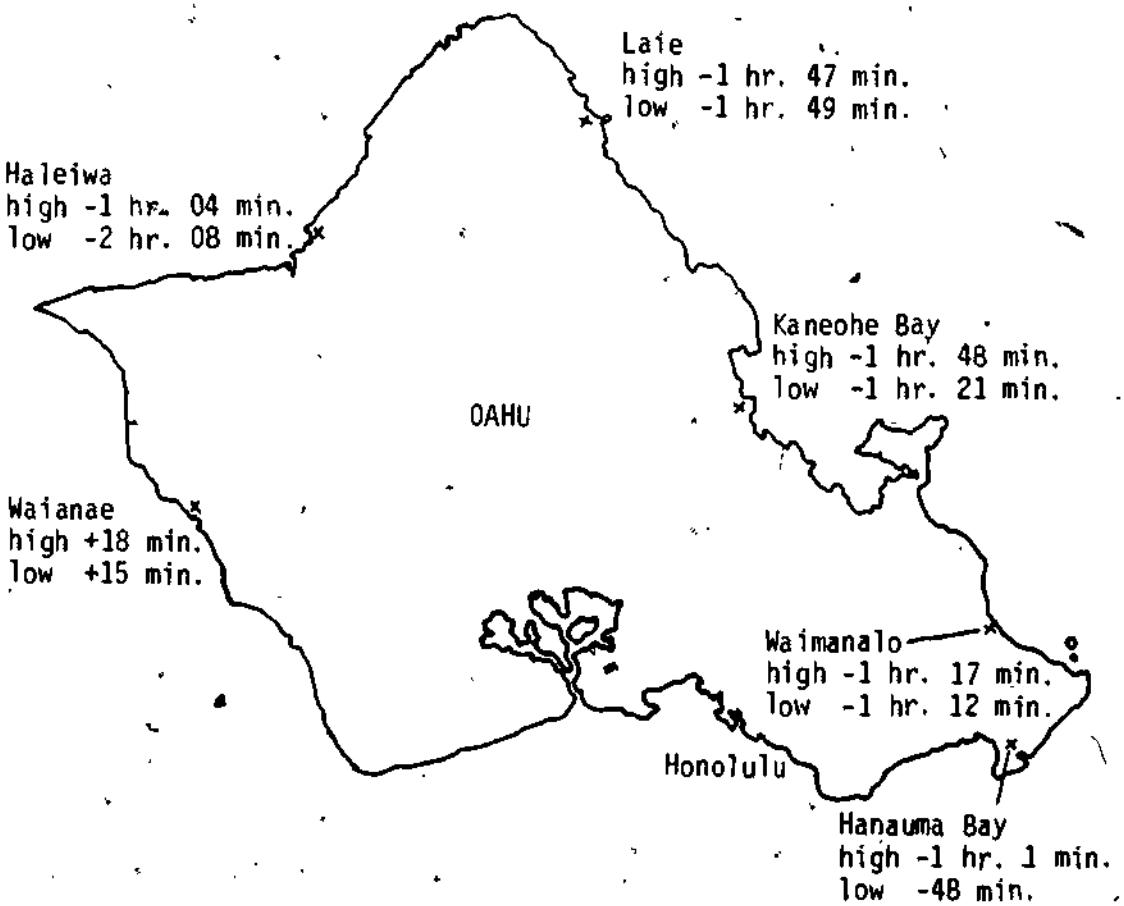
TIDE CALENDARS

You may be familiar with the "Dillingham Tide Calendar", available from the Dillingham Corporation. This calendar expresses the tidal change as a wavy line over a time-height grid. This is a good tool for "eye-balling" the tide, but copies are in short supply. Also, the adjustment times for other parts of the island are averages of the time differences of high and low tide. For example, in Haleiwa high tide occurs 1 hour and 4 minutes earlier than in Honolulu, and low tide occurs 2 hours and 8 minutes earlier. The tide calendar shows the adjustment to be 1 hour and 38 minutes earlier. By using this figure you would have miscalculated the low tide by a half an hour. However, as long as you understand the time adjustment problem, the "Dillingham Tide Calendar" is great if you can get it.

Tide calendars are also published in the monthly Marine Advisory Program Newsletter "Makai" available from University of Hawaii Sea Grant College, 2540 Maile Way, Spalding Hall 252 B, Honolulu, Hawaii 96822.

If you need any assistance in understanding the tides, call the Education Department of the Waikiki Aquarium.

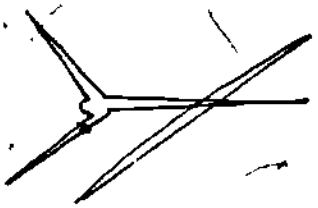
The times of the tides given in the tide table or on a tide calendar are for Honolulu. To calculate the accurate time of the tide for other areas on Oahu, use the time changes given on this map.



PHYLUM PORIFERA
SPONGES

UPRIGHT SPONGE

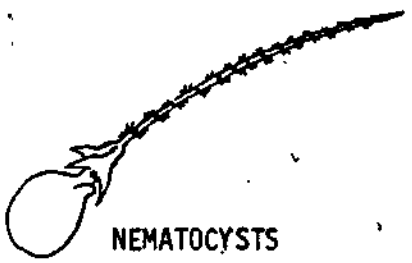
Sponges are the simplest of the animals made from more than one cell. They don't move and are always attached to something. They may be upright (like a simple bush) or encrusting (flattened). They are often brightly colored. They have many small holes by which food and water enter the body, and several large ones by which the water and wastes exit.



SPONGE SPICULES

Sponges have skeleton elements called spicules. These tiny glass rods can be irritating to human skin. You can examine the spicules by putting a little Clorox on a small piece of sponge. This dissolves the tissue so you can look at the spicules with a microscope.

PHYLUM COELENTERATA (=CNIDARIA)
SEA ANEMONES, CORAL, JELLYFISH, HYDROIDS



NEMATOCYSTS

Coelenterates are soft bodied. The individual animals are radially symmetrical (round, like a pie) with a ring of tentacles around a central mouth. The tentacles have stinging cells (nematocysts) for food gathering and protection. This group has two basic body forms: the polyp and the medusa.

SEA ANEMONES

Sea anemones illustrate the polyp form of this group. A polyp has an upright stalk with the mouth and tentacles directed upwards. Zoanthids are colonies of anemone-like animals which share tissue. They form soft mats of living animals.

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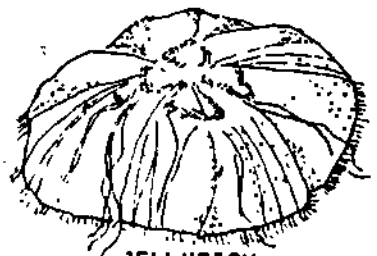
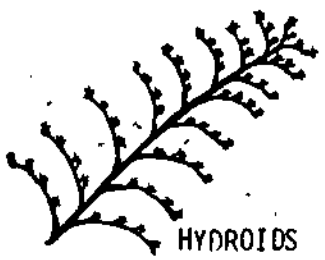


JELLYFISH

Jellyfish illustrate the medusa form. There is no stalk, only a bell-like structure with the mouth and the tentacles on the undersurface of the bell. Jellyfish swim by muscular contractions of the bell. Some can give a painful sting.

CORAL

Corals are colonies of anemone-like animals which secrete a hard, calcium carbonate ($CaCO_3$), skeleton. Reef-building corals have tiny, one-celled algae living in their tissue. These algae aid in the formation of the hard skeleton.

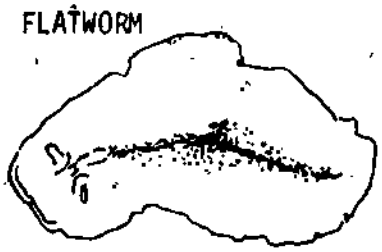


HYDROIDS

Hydroids are colonies of polyps which form a plant-like structure. The stems and branches of the colony are hollow and food and water are passed through them. Hydroids can sting and should not be handled.

PHYLUM PLATYHELMINTHES
FLATWORMS

FLATWORM



Flatworms are bilaterally symmetrical (having a right and left side) and very flat. They glide along by secreting a sheet of mucous and beating small hairs on their undersurface on this mucous sheet. Some can swim also. They are very thin so that wastes can pass from the body interior through the skin.

PHYLUM ANNELIDA
SEGMENTED WORMS

BRISTLE WORM

Annelid worms are bilaterally symmetrical and segmented. some structures, like muscles and kidneys, are repeated in each segment. Marine annelids are called polychaetes (=many bristles) because they have spines or bristles along the sides. These may be used for protection or for holding on in a tube. Some annelids, like the bristle worm are free-living and are found under rocks.

FEATHERDUSTER WORM

Tube worms, featherduster worms, and spaghetti worms are annelids which secrete a protective tube. They stay in this tube and extend tentacles or fans from the head end to catch food. When frightened, they can draw this food catching apparatus in rapidly.

PHYLUM ECHINODERMATA
STARFISH, SEA URCHINS,
SEA CUCUMBERS, BRITTLE STARS

STARFISH

Echinoderms are basically built on a 5 ray plan. This plan is evident in starfish and brittle stars, and can be seen on sea urchin tests (=shells). Echinoderms are the only group that has tube feet for locomotion and/or attachment. This group exhibits a high degree of ability to regenerate lost body parts. Starfish usually have 5 arms or at least 5 sides, but some, like the crown-of-thorns, have many arms. There is a row of tube feet on the undersurface of every arm. The digestive and reproductive systems extend into the arms. Starfish eat by extruding a thin, pouch-like stomach over their prey.

PHYLUM MOLLUSCA
SNAILS, SLUGS, CLAMS OYSTERS, SQUID, OCTOPUS, ETC.

SNAIL

Mollusks have a soft body which is usually proctected by a shell. The shell may be single or paired.

CLAM

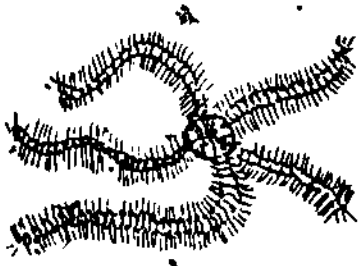
Mollusks have a mantle which secretes the shell, and which, in the cowries, can cover the shell. The foot is a muscular structure which is used for crawling or digging (as in clams). Mollusks also have eyes and rhinophores (chemically sensitive tentacles on the head). Cones are snails which catch their prey with a venemous dart. Nudibranchs and sea hares are also termed sea slugs, because they are snails with only tiny shells or none at all. They are often very colorful.

OCTOPUS

Octopus, cuttlefish, chambered nautilus, and squid are all mollusks that feed with tentacles. The chambered nautilus is the most primative and ancient member of this group and retains a large shell. The octopus is the most highly evolved member, having a highly developed nervous system and no shell. Both the octopus and cuttlefish are able to change color and texture rapidly.

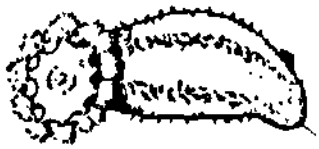
PHYLUM ARTHROPODA
BARNACLES, SHRIMP, LOBSTERS, CRABS

Arthropods have jointed legs and hard body coverings which they must molt periodically in order to grow. During molting the hard body covering is shed, exposing a new, soft one underneath. This hardens in a short time. Most



BRITTLE STAR

Brittle stars look like skinny, black starfish, but are really quite different. Their body and arms are distinctly separate, they can drop their arms at will, their digestive and reproductive systems do not extend into the arms, the arms are lined with spines, and the tube feet do not have suction cups on the ends as they do in starfish. Brittle stars are commonly found under rocks.



SEA CUCUMBER

Sea cucumbers have an elongate body with the mouth and anus at opposite ends. The mouth is ringed with food gathering tentacles. Sometimes a small black and white crab may be found in the mouth. Certain kinds of sea cucumbers spit out sticky white threads when disturbed. Tube feet are found all over the undersurface of most Hawaiian sea cucumbers, helping them to hang onto rocks. Sea cucumbers breathe by pumping water in and out of the anus. Their respiratory mechanism is inside the body near the anus.

SEA URCHIN

Sea urchins are usually spiny. Most are harmless unless you fall or step on them, but the ones with long, thin spines are venemous. All sea urchins are edible, the gonads being the part that is eaten. Sea urchins eat with 5 hard teeth found in the center of the underside of the body. These are part of a larger internal structure called an Aristotle's lantern. Sea urchins have rows of tube feet among their spines.

FEATHER STAR

Crinoids are the most ancient members of this group. They are also called feather stars. Unlike their relatives their mouth is on the top rather than underneath. Food particles are caught on the feathery arms and moved to the mouth.

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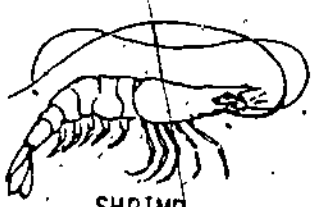
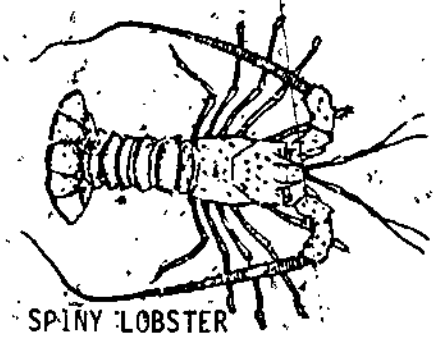
marine arthropods are termed crustacea (not barnacles though).



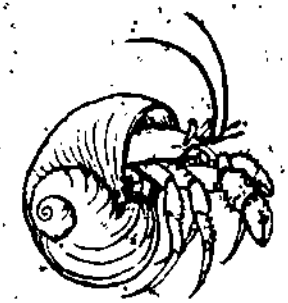
SHRIMP

Shrimps have a long abdomen and 5 pairs of legs. They have 2 pair of antennae and a rostrum, or point between the eyes. Usually one, two and sometimes three pairs of legs have pincers. The mouthparts are several pairs of modified legs. Large, edible shrimp are called prawns.



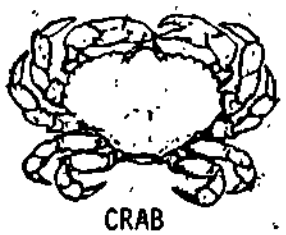
SPINY LOBSTER

Spiny lobsters have 5 pairs of legs and no pincers. One pair of antennae is enlarged greatly, and has a spiny base; this structure is used in encounters with other animals. Slipper lobsters are flattened lobsters with no pincers. These are closely related to spiny lobsters. True or Maine lobsters have pincers on the first pair of legs and are not closely related to spiny lobsters.



HERMIT CRAB

Hermit crabs have a reduced and softened obdomen which they usually cover with a mollusk shell. Some species of hermits have sea anemones that live on the shell. These probably help protect the hermit crab from predators because they have stinging cells.



CRAB

Crabs have a totally reduced abdomen. All that is left of it is a flap under the body which covers the reproductive structures. Crabs exhibit many adaptations to different life styles. Swimming crabs have the last pair of legs paddle shaped. Rock crabs are flattened and have spines on the legs for hanging onto rocks in the surf zone. Box crabs and Kona crabs are adapted for burrowing in the sand. Some crabs have long eyestalks for peering out of the mud on sand in which they live. Many crabs are semi-terrestrial meaning they are adapted to live out of water for extended periods.

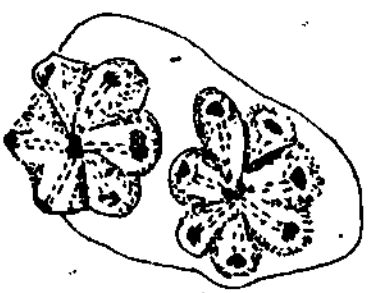
BARNACLES

Adult barnacles don't look like other members of this group, but when they are in the larval stages, they look like small shrimp. They settle out on a hard surface and form their stony house around themselves. The 2 door at the top open during high tide to allow the feathery feet to catch small animals in the plankton.

SEA SQUIRT

PHYLUM CHORDATA, SUBPHYLUM URDCHORDATA
TUNICATES OR SEA SQUIRTS

Sea squirts and colonial tunicates are in the phylum chordata (along with you and I) because they have Chordate characteristics during the larval stages. Some of these characteristics are gill slits and a notocord. In the adult stage, however, they look like very simple animals. A sea squirt is a single individual with 2 openings into the body, one for the entrance of water and food and one for exit of water and wastes. Sea squirts are sessile organisms, which means they are permanently attached. If you squeeze them, water will squirt out.



COLONIAL TUNICATES

Colonial tunicates are colonies of tiny, sea squirt-type animals. Often they form themselves into petal-like arrangements. This is done so they can share a common waste exit. Some of these colonies are as big and fat as a softball, others are very thin. They are often colorful.